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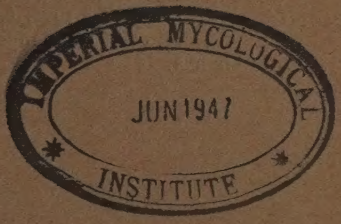

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MATHÉMATIQUES

SUR UNE CLASSE DES GÉOMÉTRIES INTRINSÈQUES INDUITES SUR UNE SURFACE DANS UN ESPACE À CONNEXION AFFINE

Par G. LAPTEV

(Présenté par N. N. Lusin, de l'Académie, le 12. VIII. 1943)

§ 1. Soit A_N une multiplicité à N dimensions des points définis par le système des valeurs de N variables $x', \ldots, x^N$. Attachons au point mobile $M(x)$ de cette multiplicité un espace affine local $\mathfrak{A}_N(x)$ à N dimensions, défini par un système des vecteurs $\vec{e}_1(x), \ldots, \vec{e}_N(x)$ à l'origine $M(x)$, que nous appellerons le repère mobile de la multiplicité A_N. Considérons une représentation affine de l'espace $\mathfrak{A}_N(x+dx)$ aux propriétés suivantes:

1. Le repère $M(x+dx); \vec{e}_1(x+dx), \ldots, \vec{e}_N(x+dx)$ de l'espace $\mathfrak{A}_N(x+dx)$ correspond au certain repère $M(x; dx); \vec{e}_1(x; dx), \ldots, \vec{e}_N(x; dx)$ de l'espace $\mathfrak{A}_N(x)$, défini en cet espace par des paramètres qui sont des fonctions dérivables des $dx', \ldots, dx^N$ pour $dx' = \ldots = dx^N = 0$ et qui ont les parties principales par rapport aux $dx', \ldots, dx^N$ dépendant analytiquement des $x', \ldots, x^N$.

2. $M(x)$ et $M(x+dx)$ étant deux points infiniment voisins, les repères $M(x; dx); \vec{e}_1(x; dx), \ldots, \vec{e}_N(x; dx)$ et $M(x); \vec{e}_1(x), \ldots, \vec{e}_N(x)$ sont deux repères infiniment voisins également.

3. Les parties principales des représentations de $\mathfrak{A}_N(x+dx)$ sur $\mathfrak{A}_N(x)$ établissent une correspondance ponctuelle biunivoque entre A_N et $\mathfrak{A}_N(x)$ dans le voisinage du point $M(x)$.

Cela étant, la partie principale de la représentation $\mathfrak{A}_N(x+dx)$ sur $\mathfrak{A}_N(x)$ établit dans A_N une connexion affine unique, si on ne distingue pas les connexions équivalentes. En effet, nous avons

$$\left.\begin{aligned} &\overrightarrow{M(x)\,M(x; dx)} = (\vartheta^K + \rho\varepsilon^K)\,\vec{e}_K(x) \\ &\vec{e}_K(x; dx) = \vec{e}_K(x) + (\vartheta^J_K + \rho\varepsilon^J_K)\,\vec{e}_J(x), \\ &\rho = |\vartheta'| + \ldots + |\vartheta^N|, \lim_{\rho\to 0}\varepsilon^K = 0, \lim_{\rho\to 0}\varepsilon^J_K = 0 \end{aligned}\right\} \qquad (1)$$

où les $\vartheta^K, \vartheta^J_K$ $(J, K = 1, \ldots, N)$ sont des formes linéaires homogènes des $dx', \ldots, dx^N$ dont les coefficients sont des fonctions analytiques des $x', \ldots, x^N$, et $\vartheta', \ldots, \vartheta^N$ — des formes linéairement indépendantes.

Il en suit que le déplacement infinitesimal du repère mobile $M(x); \vec{e}_1(x), \ldots, \vec{e}_N(x)$ étant la partie principale du déplacement de son image en espace local $\mathfrak{A}_N(x)$ qui correspond à la translation du point $M(x)$ en $M(x+dx)$, est défini par les vecteurs

$$d\vec{M}(x) = \vartheta^K \vec{e}_K(x); \quad d\vec{e}_K(x) = \vartheta^J_K \vec{e}_J(x). \tag{2}$$

Le système des formes ϑ^K, ϑ_K définit en A_N une certaine connexion affine [1]. Cette connexion ne dépend pas du choix de repère. En effet, attachons au point variable $M(x)$ deux repères mobiles $M(x)$; $\vec{e}_K(x)$ et $M(x)$; $\vec{e}_{K'}(x)$, où

$$\vec{e}_{K'}(x) = a'^J_{K'} \vec{e}_J(x), \tag{3}$$

$a^J_{K'}$ étant des fonctions analytiques des $x', \ldots, x^N$; représentation de $\mathfrak{A}_N(x+dx)$ sur $\mathfrak{A}_N(x)$ nous donne deux systèmes des formes ϑ^K; ϑ^J_K et $\vartheta^{K'}$; $\vartheta^{J'}_{K'}$ liés par des conditions

$$\omega^{K'} = a^{K'}_L \omega^L; \quad \omega^{J'}_{K'} = da^L_{K'} a^{J'}_L + a^L_{K'} a^{J'}_M \omega^M_L \quad (J, K, L, M = 1, \ldots, N), \tag{4}$$

où $a^L_{K'} a^{J'}_L = \delta^{J'}_{K'}$; $a^{L'}_K a^J_{L'} = \delta^J_K$. On peut voir sans difficulté que ces systèmes définissent en A_N des connexions équivalentes, et la proposition citée ci-dessus est donc établie.

§ 2. Considérons dans un espace à connexion affine à N dimensions une surface S_n à n ($n \leqslant N$) dimensions, définie par le système des équations paramétriques

$$x^K = x^K(u', \ldots, u^n) \quad (K = 1, \ldots, N), \tag{5}$$

x^K étant des fonctions analytiques de même que tous les autres fonctions dont on fera usage désormais.

Le plan tangent $\mathfrak{S}_n(u)$ à S_n en $M[x(u)]$ étant le lieu géométrique des points $d\vec{M} = \vartheta^K \vec{e}_K(x)$, où $x^K = x^K(u', \ldots, u^n)$ est situé dans $\mathfrak{A}_N[x(u)]$, prenons ce plan pour l'espace local, correspondant au point $M[x(u)]$. Considérons ensuite un certain plan $\mathfrak{S}_n(u; du)$ qui soit l'image du plan $\mathfrak{S}_n(u+du)$ en $\mathfrak{A}_N[x(u)]$. Chaque représentation du plan $\mathfrak{S}_n(u; du)$ sur le plan $\mathfrak{S}_n(u)$ satisfaisant aux conditions 1, 2, 3 du § 1 établit sur S_n une connexion affine induite par la connexion de l'espace ambiant A_N. Attachons au point mobile $M[x(u)]$ de la surface S_n une normale $\mathfrak{N}_{N-n}(u)$, c'est-à-dire un plan à $N-n$ dimensions situé en $\mathfrak{A}_N(x)$ et ayant un seul point commun avec $\mathfrak{S}_N(u)$. Étant donnée une projection de $\mathfrak{S}_n(u+du)$ sur $\mathfrak{S}_n(u)$ parallèle à ce plan, on obtient sur S_n une connexion induite établie par la projection [2]. En faisant varier la normale $\mathfrak{N}_{N-n}(u)$, on établit sur S_n un complexe de pareilles connexions. Ce complexe peut être défini par de certaines conditions suffisamment générales énoncées dans le théorème dont nous ommettons la démonstration.

Théorème. *Soit établie sur chaque surface d'un espace arbitraire à connexion affine la classe maximum des géométries intrinsèques, satisfaisant aux conditions suivantes.*

1. *Chaque géométrie intrinsèque d'une classe liée à la surface S_n est induite par la connexion de l'espace ambiant et définie par la représentation $\mathfrak{S}_n(u; du)$ sur $\mathfrak{S}_n(u)$ laissant fixes tous les points communs de ses plans.*

2. *Si l'espace A_N renferme la surface S_m renfermant à son tour la surface S_n ($N \geqslant m \geqslant n$), la classe des géométries induites sur S_n par la connexion A_N coïncide avec l'ensemble de toutes les géométries intrinsèques appartenant aux classes induites sur S_n par toutes les connexions de la classe établie sur la surface S_m.*

Cela étant, la classe maximum des géométries intrinsèques d'une surface satisfaisant aux conditions citées ci-dessus coïncide avec un complexe des connexions établies sur cette surface par la projection.

§ 3. Attachons à la surface S_n un repère mobile du 1-er ordre, ou, à dire autrement, prenons un repère mobile $M(x)$, $\vec{e}_1(x), \ldots, \vec{e}_N(x)$ de l'espace ambi-

ant A_N, dont le déplacement infinitésimal correspond à un déplacement de son origine $M(x)$ sur la surface S_n par des relations suivantes

$$\left.\begin{array}{l} \overrightarrow{dM} = \vartheta^K \vec{e}_K(x);\ \vartheta^\alpha = 0;\ \ \vec{de}_K = \vartheta^J_K \vec{e}_J(x);\ x^K = x^K(u', \ldots, u^n) \\ (i,\ k = 1, \ldots, n;\ \alpha, \beta = n+1, \ldots, N;\ J,\ K = 1, \ldots, N) \end{array}\right\} \quad (6)$$

On peut démontrer qu'une connexion affine arbitraire établie sur la surface S_n par la projection peut être définie par des formes

$$\tilde{\omega}^k = \vartheta^k;\ \omega^i_k = \vartheta^i_k + a^i_\alpha \vartheta^\alpha_k \quad (7)$$

a^i_α étant de certaines fonctions analytiques des $u', \ldots, u^n$. Inversement, a^i_α étant choisies arbitrairement, les formes (7) définissent une connexion établie sur S_n par la projection. Il en résulte que les formes Ω^i de la connexion (7) établie sur la surface par la projection sont définies par les formes θ^J de la torsion de l'espace ambiant:

$$\Omega^i = \theta^i + a^i_\alpha \theta^\alpha. \quad (8)$$

En particulier, toutes les connexions établies par la projection sur une surface d'un espace affin ont des formes de torsion nulles.

§ 4. En se rapportant à la théorie des systèmes de Pfaff de M. Cartan, on peut démontrer le théorème suivant.

Théorème. *Pour que le complexe des connexions affines établies par la projection sur une surface arbitraire non-spéciale S_n d'un espace à N dimensions renferme une connexion affine arbitraire sans torsion à n dimensions, il faut et il suffit que*

$$N \geqslant \frac{n^2+3n}{2}. \quad (9)$$

Cette condition étant satisfaite, on peut prendre pour le système de référence de ces connexions un système arbitraire de n coordonnées curvilignes de la surface S_n.

Il importe de remarquer que ce théorème donne en certain sens la résolution du problème de la possibilité de plonger les espaces de la connexion affine dans un espace affin (²).

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MATHEMATICS

ORTHOGONAL AND SYMPLECTIC REPRESENTATIONS OF SEMI-SIMPLE LIE GROUPS

By A. MALCEV

(Communicated by A. N. Kolmogoroff, Member of the Academy, 10. V. 1943)

There are various important problems of the general theory of Lie groups that can be reduced to the problem of determining all classes of conjugate semi-simple subgroups of the connected complex semi-simple Lie groups. Among such problems we note the following ones: to determine all the Lie algebras possessing the given radical; to determine the homogeneous manifolds with a compact transitive group of continuous transformations *.

The problem of determination of subgroups of a group $\mathfrak{G}$, however, may be considered as a particular case of more general problem of construction of the theory of representations in the group $\mathfrak{G}$ **. In fact, every isomorphic mapping $\mathfrak{D}$ of the given group $\mathfrak{H}$ into $\mathfrak{G}$ is called the representation of $\mathfrak{H}$ into $\mathfrak{G}$. The representations $\mathfrak{D}_1$ and $\mathfrak{D}_2$ of the group $\mathfrak{H}$ are said to be equivalent in $\mathfrak{G}$, if there exists such an element $g \in \mathfrak{G}$ that $\mathfrak{D}_2(h) = g^{-1}\mathfrak{D}_1(h)\,g$ for all $h \in \mathfrak{H}$. The image $\mathfrak{D}(\mathfrak{H})$ of the group $\mathfrak{H}$ under the mapping $\mathfrak{H} \to \mathfrak{G}$ is a subgroup in $\mathfrak{G}$ isomorphic to $\mathfrak{H}$. Conversely, if $\mathfrak{H}_1$ is a subgroup in $\mathfrak{G}$ isomorphic to $\mathfrak{H}$, then this isomorphism gives a representation of $\mathfrak{H}$ into $\mathfrak{G}$. The equivalent representations give evidently the conjugate subgroups.

The converse is not true in general and we may only state the following: if the representations $\mathfrak{D}_1$, $\mathfrak{D}_2$ of the group $\mathfrak{H}$ give one subgroup of $\mathfrak{G}$, then one of these representations can be obtained from the other by means of an automorphism σ, namely, $\mathfrak{D}_2(h) = \mathfrak{D}_1(h^\sigma)$; if σ is an inner automorphism, then $\mathfrak{D}_1$ and $\mathfrak{D}_2$ are equivalent; otherwise they are not. It is obvious that, if we find all classes of equivalent representations of $\mathfrak{H}$ into $\mathfrak{G}$ and join those of them that can be transformed one into another by outer automorphisms of $\mathfrak{H}$, we shall obtain all classes of conjugate subgroups in $\mathfrak{G}$ isomorphic to $\mathfrak{H}$. Therefore we must know the outer automorphisms of $\mathfrak{H}$ in the general case, but here we intend to deal with semi-simple subgroups only, for which the outer automorphisms are well known (2).

On the other hand, since every semi-simple group can be decomposed, at least locally, into the direct product of simple groups, it is easy to see that the problem of determination of representations in semi-simple groups is equivalent to the similar problem in simple groups.

The simple groups are well known. They can be divided into four infinite classes of the so-caled classical groups A_n, B_n, C_n, D_n $(n = 1,2,\ldots)$ and five sin-

* As follows from (3) the general problem of determination of semi-simple groups in arbitrary Lie groups is also equivalent to the more special problem stated here.

** As a matter of fact, we deal with the Lie algebras or, which is the same, with the local groups. Therefore, all the groups considered are supposed to be connected and those, the representations of which are to be found, simply connected.

gular groups E_6, E_7, E_8, F_4, G_2. Thus, to solve the above general problem it is necessary to develop the theory of representations of semi-simple groups in everyone of these simple groups.

The semi-simple subgroups of the groups F_4 and G_2 can be found by means of some properties of three-dimensional simple groups. In this note we intend to find the semi-simple subgroups of the classes A_n, B_n, C_n, D_n. As we have already seen, this is equivalent to the construction of the theory of representations of semi-simple groups in these systems. The representations in A_n are general linear representations, the theory of which has been given by Cartan [1] and Weyl [5]. Consequently, we must construct the theory of representations in C_n, i. e. the theory of symplectic representations, as well, as in B_n and D_n, i. e. of orthogonal ones. Cartan-Weyl's theory mentioned above furnishes all that is necessary for this purpose *.

Every linear representation $\mathfrak{D}$ of a semi-simple group is uniquely determined, up to equivalence in the general linear group, by the system of maximal weights of the irreducible parts of $\mathfrak{D}$ [1]. The following theorem shows that the same system of invariants—that of the weights of absolutely irreducible parts—characterizes also the representations in $O(n)$ and $Sp(n)$**.

Theorem 1. *If two representations of a connected group $\mathfrak{G}$ by orthogonal or symplectic matrices are equivalent in the general linear group; they are also equivalent in $O(n)$ and $Sp(n)$, respectively* ***.

Here we note the following. We are interested in the representations that are equivalent in the connected Lie groups. But $O(n)$ can be decomposed into two components: the group $O^+(n)$ of proper orthogonal representations with the determinants $+1$ and the set of non-proper orthogonal transformations. When n is odd, the equivalence in $O(n)$ implies that in $O^+(n)$. But in case n is even, the class of representations equivalent in $O(n)$ can be decomposed into two classes of representations equivalent in $O^+(n)$, everyone of which can be carried into the other by a non-proper orthogonal transformation. If we disregard this lack of uniqueness in $O^+(n)$, we may say that both the orthogonal and the symplectic representations are characterized by their Cartan weights. It remains to make clear what system of weights gives the orthogonal representation and what the symplectic one. A preliminary result in this direction is given by

Theorem 2. *If an orthogonal or a symplectic representation of a semi-simple group is decomposed into two parts, one of which is orthogonal or, respectively, symplectic, then the other one is of the same kind. The orthogonal and the symplectic representations of the semi-simple groups are decomposed in $O^+(n)$ or $Sp(n)$, respectively, into orthogonally or symplectically irreducible parts.*

The orthogonal and the symplectic representations may be irreducible in the orthogonal or, respectively, in the symplectic groups, being reducible at the same time in the complete linear group. The structure of such representations can easily be described by means of the well known notion of contragredience. Namely, if $g \to \mathfrak{D}(g)$ is a representation of the group $\mathfrak{G}$, then the correspondence $g \to \mathfrak{D}^{*-1}(g)$ is also a representation of $\mathfrak{G}$ which is contragredient or dual to the first one.

Theorem 3. *An orthogonally irreducible, orthogonal representation of a semi-simple group is either absolutely irreducible or equivalent to the sum of two contragredient absolutely irreducible representations. The same is true for the symplectic representations. The sum of two contragredient representations is both orthogonal and symplectic.*

---

* Orthogonal and symplectic representations of the three-dimensional simple group $A_2 = C_1$ were determined by F. Gantmacher in a paper reviewed in [3].

** The group of all linear transformations of the n-dimensional space leaving invariant a non-degenerate symmetric bilinear form is denoted by $O(n)$. The analogous group of transformations of the $2n$-dimensional space with an invariant non-degenerate skew-symmetric form, is called symplectic and is denoted by $Sp(n)$. The Lie algebras for $Sp(n)$, $O(2n)$ and $O(2n+1)$ are C_n, D_n and B_n, respectively.

*** As to the equivalence in $O(n)$, Theorem 1 was proved by Frobenius [4].

Theorem 4. *The representation $\mathfrak{D}$ of the group $\mathfrak{G}$ possesses an invariant non-degenerate bilinear form if and only if $\mathfrak{D}$ is equivalent to its contragredient representation.*

In particular, if a representation is absolutely irreducible and self-contragredient, then it is either orthogonal or symplectic. It is also easy to see that an absolutely irreducible representation cannot be orthogonal and symplectic at the same time.

The Cartan weights are determined by the representation of the infinitesimal group. For the infinitesimal group the notion of contragredience is transformed into the following one. The representation contragredient to $\mathfrak{D}$ is—$\mathfrak{D}^*$. It is easily seen that the weights of—$\mathfrak{D}^*$ are equal to those of $\mathfrak{D}$ with the opposite sign. Hence Theorem 4 yields the following result. *In order that an irreducible representation $\mathfrak{D}$ possess an invariant non-degenerate bilinear form, it is necessary and sufficient that the maximal weight of $\mathfrak{D}$ be equal to the minimal weight of the same representation with the opposite sign.* Two irreducible representations are contragredient, if the maximal weight of one of them is equal to the minimal weight of the other one with the opposite sign.

Till now we have dealt with representations of semi-simple groups. In what follows we may restrict ourselves to the consideration of simple groups. In fact, every semi-simple group is representable as the direct product of simple groups, and every representation of a direct product is the Kronecker product of the direct factors. As to the orthogonality, the symplecticality and the contragredience of the Kronecker product, they are immediately reduced to the corresponding properties of the factors.

The weights of the irreducible representations of simple groups were found by Cartan ([1]). Using Theorem 4, one can easily determine which of them are self-contragredient. A more delicate problem is to determine which of the self-contragredient weights correspond to the symplectic and which to the orthogonal representations. But all irreducible representations can be obtained from the so-called «basic» representations by forming their Kronecker product and the subsequent decomposition into the irreducible parts ([1]). The following lemma enables us to determine the behaviour of all representations, when that of the basic ones is known.

Lemma. *The Kronecker product of two contragredient representations is orthogonal. In particular, the product of two symplectic or of two orthogonal representations is orthogonal. The Kronecker product of two representations, one of which is orthogonal and the other one symplectic, is symplectic. The alternations of an orthogonal representation are orthogonal. The alternations of even order of a symplectic representation are orthogonal, those of odd order are symplectic.*

As to the behaviour of basic representations, it can be determined by particular methods. The following results are obtained.

Groups A_n. To the weight $\Lambda = p_1\lambda_1 + \ldots + p_n\lambda_n$ the weight $\Lambda^* = p_1\lambda_1 + (p_1 - p_n)\lambda_2 + (p_1 - p_{n-1})\lambda_3 + \ldots + (p_1 - p_2)\lambda_n$ is contragredient. If $n = 4k$, $n = 4k+2$ or $n = 4k+3$, then every self-contragredient representation of A_n is orthogonal. When n is of the form $4k+1$, then the self-contragredient weight is orthogonal or symplectic, according as the coefficient p_1 is even or odd.

Groups B_n. All representations of the groups B_{4k}, B_{4k+3} are orthogonal. The irreducible representations of B_{4k+1} and B_{4k+2} with integral weights are symplectic.

Groups C_n. The irreducible representations of C_n, the sum of coefficients of which is even, are orthogonal, the other ones are symplectic.

Groups D_n. All representations of D_{4k}, D_{4k+1}, D_{4k+3} are orthogonal. The irreducible representations of D_{4k+2} with integral weights are orthogonal, those with fractional weights are symplectic.

Group E_6. To the weight $\Lambda = p_1\lambda_1 + \ldots + p_6\lambda_6$ the weight $\Lambda^* = \left(\frac{1}{3}\sum_\alpha p_\alpha - p_6\right)\lambda_1 + \ldots + \left(\frac{1}{3}\sum_\alpha p_\alpha - p_1\right)\lambda_6$ is contragredient. All self-contragredient representations of E_6 are orthogonal.

Group E_7. Every irreducible representation of E_7, the maximal weight of which has integral coefficients, is orthogonal. All the other irreducible representations of E_7 are symplectic*.

Groups E_6, F_4, G_2. All representations of E_8, F_4 and G_2 are orthogonal.

To obtain the classification of semi-simple groups from these results, it is necessary, as was stated above, to join the representations which can be transformed one into another by outer automorphisms. Among all the simple groups A_n, D_n, E_6 only possess outer automorphisms. Each of them, except D_4, possesses a unique outer isomorphism, up to inner automorphism. It is easily seen from the form of this automorphism that it carries the representation of weight Λ into that of contragredient weight Λ^*. Thus, to the contragredient weights (resp. to the contragredient systems of weights) there correspond the classes of conjugate subgroups in one-to-one manner**.

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* The weights are everywhere in the Cartan form.

** In the group D_n, as was noted, two classes of subgroups may correspond to the weight.

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MECHANICS

CONTRIBUTION TO THE QUESTION OF DETERMINING THE EFFICIENCY OF A GEARING

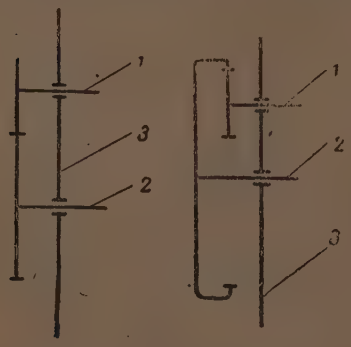
By M. KREINES

(Communicated by S. L. Soboleff, Member of the Academy, 17. VIII. 1943)

This paper is concerned with the deduction of a formula for computing the efficiency of a statically determinable gearing with one degree of freedom. In deriving this formula only the losses due to friction between the teeth of the wheels in mesh are taken into consideration, and all the other losses of energy inside the mechanism are supposed to be small and are not allowed for.

The results of this work should be considered as the further development of the results obtained by Brandenberger in 1929 (1).

§ 1. Preliminary Remarks. A most simple kind of plane gearing is represented by the three-link mechanisms shown schematically in the annexed figure. The ratio each of them sets up between the angular velocities ω_1, ω_2 and ω_3 of the three respective links 1, 2 and 3 is



$$\omega_1 - i'\omega_2 + (i'-1)\omega_3 = 0, \qquad (1)$$

where i' is the transmission ratio from gear 1 to gear 2 when planet carrier 3 is stopped.

On our assumptions, if the angular velocities of the links are constant and the mechanism is in equilibrium, then one of the moments $\tilde{M}_1$ and $\tilde{M}_2$ applied externally to the gears 1 and 2 will be determined completely as soon as the other is known, and the direction of the relative velocity of either the gear 1 or 2 with respect to the planet carrier 3 is given.

From what has been just said it follows that in determining the moment $\tilde{M}_2$ from a given moment $\tilde{M}_1$ the angular velocity of the planet carrier 3 may be taken to be zero and the angular velocities of the gears 1 and 2 equal to $\omega_1 - \omega_3$ and $\omega_2 - \omega_3$, respectively. Making use of that we obtain

$$\tilde{M}_1(\omega_1 - \omega_3)\eta^x + \tilde{M}_2(\omega_2 - \omega_3) = 0$$

where η is the efficiency of a pair of wheels with axes immovable in space and $x = \operatorname{sgn} \tilde{M}_1(\omega_1 - \omega_3)$ *. By means of (1) we obtain further

* The symbol sgn A denotes $+1$ if $A>0$, and -1 if $A<0$; sgn $0=0$.

$$\tilde{M}_1 \tilde{i}' + \tilde{M}_2 = 0, \text{ where } \tilde{i}' = i' \eta^x. \quad (2)$$

For determining the moment $\tilde{M}_3$ applied from without to the planet carrier 3 we use the theorem on the derivative of the sum of angular momenta with respect to time. The application of this theorem to the mechanism under consideration gives

$$\tilde{M}_1 + \tilde{M}_2 + \tilde{M}_3 = 0. \quad (3)$$

The conditions of equilibrium of the gearing given by formulae (2) and (3) are ultimately rewritten thus

$$\frac{\tilde{M}_1}{1} = \frac{\tilde{M}_2}{\tilde{i}'} = \frac{\tilde{M}_3}{\tilde{i}' - 1}, \text{ where } \tilde{i}' = i' \eta^x. \quad (4)$$

The power $\Delta = \tilde{M}_1 \omega_1 + \tilde{M}_2 \omega_2 + \tilde{M}_3 \omega_3$ lost in the simplest type of gearing on account of friction can after transformations by means of (1) and (4) be represented in the form

$$\Delta = \tilde{M}_1 (\omega_1 - \omega_3)(1 - \eta^x), \text{ where } x = \operatorname{sgn} \tilde{M}_1 (\omega_1 - \omega_3). \quad (5)$$

It follows from (5) that the sign of the exponent $x = \pm 1$ in the formula $\tilde{i}' = i' \eta^x$ may be chosen to make Δ a positive value.

§ 2. Efficiency of a Gearing with one Degree of Freedom. We shall examine a general statically determinable gearing with one degree of freedom, composed of a certain number n of simplest gearings $K_1, K_2, \ldots, K_n$, the planet carriers of which are either fixed or turn about axes that make no motion in space. Such kind of mechanism must obviously consist of $n+2$ links, the immovable link inclusive.

Let us adopt the following notations: $C_0, C_\infty, C_1, C_2, \ldots, C_n$ are the driving, the driven and the remaining gears; ω_p is angular velocity of the link C_p $(p = \infty, 0, 1, 2, \ldots, n)$; M_0 and M_∞ are those values of the moments applied externally to the gears C_0 and C_∞, which satisfy the equilibrium conditions set up without allowance for friction; $M_{p,r}$, where $p = 0, 1, 2, \ldots, n, \infty$ and $r = 1, 2, \ldots, n$, is the moment carried to the gearing K_r by the gear C_p, which likewise satisfies the conditions of equilibrium making no allowance for friction; $\tilde{M}_p$ and $\tilde{M}_{p,r}$ are the values of the respective moments satisfying such equilibrium conditions as involve allowance for friction; $\eta_{0\infty}$ and $i_{0\infty} = \frac{\omega_0}{\omega_\infty} = -\frac{M_\infty}{M_0}$ are the efficiency of the gearing and its (kinetic) transmission ratio, respectively; $\tilde{i}_{0\infty} = -\frac{\tilde{M}_\infty}{M_0}$ is the altered (dynamic) transmission ratio of the gearing; η_r and i_r' are the efficiency and the transmission ratio of the gearing K_r when the planet carrier is stopped; $\tilde{i}_r' = i_r' \eta_r^{x_r}$ $(x_r = \pm 1)$ is the altered transmission ratio of the gearing K_r when the planet carrier is at rest; α_r is the ratio between the power lost by friction in the gearing K_r and that supplied to the gear C_0 from without.

In this notation

$$\eta_{0\infty} = -\frac{\omega_\infty \tilde{M}_\infty}{\omega_0 M_0} = \frac{\omega_\infty \tilde{M}_\infty}{\omega_\infty M_\infty} = \frac{\tilde{M}_\infty}{M_\infty},$$

where

$$\eta_{0\infty} = \frac{\tilde{i}_{0\infty}}{i_{0\infty}}. \quad (6)$$

Formula (6) shows that *the efficiency of the gearing is the quotient of its altered (dynamic) transmission ratio by its kinematic transmission ratio.*

In determining the quantity $\tilde{i}_{0\infty}$ we take C_n for the immovable link and proceed to set up the conditions of equilibrium. We start from the gearing K_1 and introduce a set of auxiliary quantities $\tilde{a}_{1\infty}$, $\tilde{a}_{10}$, $\tilde{a}_{11}$, $\tilde{a}_{12}$, ..., $\tilde{a}_{1n}$ in the following way. Let K_1 consist of planet carrier C_r and two gears C_p and C_q; then put $\tilde{a}_{1p}=1$, $\tilde{a}_{1q}=-\tilde{i}'_1$ and $\tilde{a}_{1r}=\tilde{i}'_1-1$, and take the rest of the quantities $\tilde{a}_{1\infty}$, $\tilde{a}_{10}$, ..., $\tilde{a}_{1n}$ to be equal to zero. Formulae (4) show that the moments $\tilde{M}_{p1}$, $\tilde{M}_{q1}$ and $\tilde{M}_{r1}$ are proportional to $\tilde{a}_{1p}$, $\tilde{a}_{1q}$ and $\tilde{a}_{1r}$, respectively. Denoting the factor of proportionality by $\tilde{\mu}_1$, write the conditions of equilibrium of the gearing K_1 as follows: $\tilde{M}_{\infty 1}=\tilde{a}_{1\infty}\tilde{\mu}_1$, $\tilde{M}_{01}=\tilde{a}_{10}\tilde{\mu}_1$, $\tilde{M}_{11}=\tilde{a}_{11}\tilde{\mu}_1$, $\tilde{M}_{21}=\tilde{a}_{12}\tilde{\mu}_1$, ..., $\tilde{M}_{n1}=\tilde{a}_{1n}\tilde{\mu}_1$.

Dealing similarly with the conditions of equilibrium of the gearings K_2, K_3, ..., K_n, we arrive at the system

$$\tilde{M}_{p,r}=\tilde{a}_{r,p}\tilde{\mu}_r, \text{ where } r=1, 2, \ldots, n \text{ and } p=0, 1, 2, \ldots, n, \infty. \tag{7}$$

The complete system of equilibrium conditions is obtained by supplementing the equations (7) with the conditions for the equilibrium of the individual gears; these conditions, on the assumption that no moments are applied to the gears $C_1, C_2, \ldots, C_{n-1}$ from without, may be written thus:

$$\sum_{r=1}^{n}\tilde{M}_{\infty r}=\tilde{M}_{\infty}, \quad \sum_{r=1}^{n}\tilde{M}_{0r}=M_0, \quad \sum_{r=1}^{n}\tilde{M}_{\rho,r}=0, \text{ where } p=1, 2, \ldots, n-1. \tag{8}$$

From (7) and (8) follows

$$-\tilde{i}_{0\infty}=\frac{\tilde{M}_{\infty}}{M_0}=\frac{\begin{vmatrix} \tilde{a}_{1\infty} & \tilde{a}_{2\infty} & \ldots & \tilde{a}_{n\infty} \\ \tilde{a}_{11} & \tilde{a}_{21} & \ldots & \tilde{a}_{n1} \\ \tilde{a}_{12} & \tilde{a}_{22} & \ldots & \tilde{a}_{n2} \\ \ldots & \ldots & \ldots & \ldots \\ \tilde{a}_{1n-1} & \tilde{a}_{2n-1} & \ldots & \tilde{a}_{nn-1} \end{vmatrix}}{\begin{vmatrix} \tilde{a}_{10} & \tilde{a}_{20} & \ldots & \tilde{a}_{n0} \\ \tilde{a}_{11} & \tilde{a}_{21} & \ldots & \tilde{a}_{n1} \\ \tilde{a}_{12} & \tilde{a}_{22} & \ldots & \tilde{a}_{n2} \\ \ldots & \ldots & \ldots & \ldots \\ \tilde{a}_{1n-1} & \tilde{a}_{2n-1} & \ldots & \tilde{a}_{nn-1} \end{vmatrix}}$$

This relation shows that $\tilde{i}_{0\infty}$ depends on no other quantities but $\tilde{i}'_1, \tilde{i}'_2, \ldots, \tilde{i}'_n$. We shall write this fact thus

$$\tilde{i}_{0\infty}=-\frac{\tilde{M}_{\infty}}{M_0}=f(\tilde{i}'_1, \tilde{i}'_2, \ldots, \tilde{i}'_n). \tag{9}$$

For $\eta_1=\eta_2=\ldots=\eta_n=1$ the relation (9) gives

$$i_{0\infty}=-\frac{M_{\infty}}{M_0}=f(i'_1, i'_2, \ldots, i'_n). \tag{10}$$

A comparison of (9) and (10) shows that *in order to obtain the value of* $\tilde{i}_{0\infty}$ *we have to replace* $i'_1, i'_2, \ldots, i'_n$ *by* $\tilde{i}'_1, i'_2, \ldots, \tilde{i}'_n$ *in the formula expressing* $i_{0\infty}$ *through* $i'_1, i'_2, \ldots, i'_n$.

From formula (6) *it may be concuded that the efficiency of a gearing may be said to give a measure of the stability of its transmission ratio.* In fact, it follows from (6), (9) and (10) that if the quantity $i_{0\infty} = f(i'_1, i'_2, \ldots, i'_n)$ is stable for small changes of the numbers $i'_1, i'_2, \ldots, i'_n$, then the replacement of these numbers by their altered values $\tilde{i}'_1, \tilde{i}'_2, \ldots, \tilde{i}'_n$ will cause only a slight relative variation of the quatity $i_{0\infty}$, and the efficiency will be close to unity.

§ 3. Determination of $\tilde{i}'_1, \tilde{i}'_2, \ldots, \tilde{i}'_n$. The values of the exponents $x_1, x_2, \ldots, x_n$ in the formulae $\tilde{i}'_r = i'_r \eta_r^{x_r}$ should, as follows from § 1, satisfy inequalities

$$\delta_1 > 0,\ \delta_2 > 0, \ldots,\ \delta_n > 0. \tag{11}$$

With every system of the numbers $x_1 = \pm 1,\ x_2 = \pm 1, \ldots, x_n = \pm 1$ *such as satisfies the inequalities* (11) *we have our gearing in equilibrium*, according to § 1. If the inequalities (11) are incompatible, no state of equilibrium is possible with velocities different from zero.

For values of $\eta_1, \eta_2, \ldots, \eta_n$ *sufficiently near to unity (and it is these values that are of the greatest interest) the inequalities* (11) *always have solutions which are moreover unique solutions.*

This solution is given by the formulae

$$x_s = \operatorname{sgn} \frac{i'_s}{i_{0\infty}} \frac{\partial i_{0\infty}}{\partial i'_s}, \qquad \text{where } s = 1, 2, \ldots, n. \tag{12}$$

Suppose, indeed, the gearing K_s to consist of the planet carrier C_r and the gears C_ρ and C_q. Then $\delta_s = \frac{\tilde{M}_{ps}(\omega_p - \omega_r)}{M_0 \omega_0}(1 - \eta_s^{x_s})$ and $x_s = \operatorname{sgn} \frac{\tilde{M}_{ps}(\omega_p - \omega_r)}{M_0 \omega_0}$. If the values of $\eta_1, \eta_2, \ldots, \eta_n$ are so close to unity that M_{ps} and $\tilde{M}_{ps}$ have the same sign, then

$$x_s = \operatorname{sgn} \frac{M_{ps}(\omega_p - \omega_r)}{M_0 \omega_0}. \tag{13}$$

We differentiate both sides of the equation

$$\frac{\tilde{i}_{0\infty}}{i_{0\infty}} = \eta_{0\infty} = 1 - \delta_1 - \delta_2 - \ldots - \delta_n$$

with respect to η_s and put $\eta_1 = \eta_2 = \ldots = \eta_n = 1$ to obtain after simple transformations

$$\frac{M_{ps}(\omega_p - \omega_r)}{M_0 \omega_0} = \frac{i'_s}{i_{0\infty}} \frac{\partial i_{0\infty}}{\partial i'_s}. \tag{14}$$

The comparison of (13) and (14) proves the formula (12).

It may be remarked in conclusion that it is merely for the sake of simplicity that we restricted our discussion to the case of plane gearings. It is easy to realize that all of the results obtained apply as well to gearings composed of wheels with non-parallel axes.

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TECHNICAL PHYSICS

RESOLUTION LIMIT OF PHOTOGRAPHIC OPTICAL INSTRUMENTS

By L. P. MOROZ

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A decrease of angular distance a between two details of a test-object, the contrast value of which $K_t = 1 - \frac{I_d}{I_l}$ remains invariable, results in decreasing the contrast $K = 1 - \frac{E_d}{E_l}$ of the optical image of these details. Here I_d, I_l are brightnesses of the dark and the light detail, respectively. E_d, E_l are illuminations in the centre of the images of these details.

The function $K = K(a)$ can be constructed if the properties of the optical system are given. On the other hand, the resolving power N'_s of the sensitized layer ($[N'_s] = \text{mm}^{-1}$) is a function of K. The angular resolution limit α of a photographic optical instrument is determined by the intersection point of the functions $a = a(K)$ and $\alpha_s = \alpha_s(K)$; α_s is the angular resolution limit of the sensitized layer, or that angular distance between two details of the test-object, which corresponds to the value of N'_s. The shape of the function $a = a(K)$ for different values of K_t has been obtained with an optical system having no aberration. The function $N'_s = N'_s(K_t)$ (N'_s is determined for $K_t \equiv K$) has been described by Sandvik [1] and by Frieser and Linke: $N'_s = K_t N'_{0s}$, where $N'_s|_{K_t=1} = N'_{0s}$.

The angular limit of resolution α_0 of the optical system of the instrument is defined as $\alpha|_{\alpha_1=0} = \alpha_0$. It is described by the Rayleigh formula [2] in case the photographic treatment is conducted with a development factor that is close to unity.

Accordingly, $\alpha|_{\alpha_0=0} = \alpha_s$. The quantity $\frac{\alpha}{\alpha_0}$ is a function of $\frac{\alpha_s}{\alpha_0}$. The curve representing this function has been obtained by computation and checked by experiment. It is described by the formula (see figure):

$$\frac{\alpha}{\alpha_0} = \frac{\alpha_s}{\alpha_0}\left(1 - e^{-\frac{\alpha_s}{\alpha_0}}\right)^{-1}. \qquad (1)$$

The quantity $\frac{\alpha_s}{\alpha_0}$ is

$$\frac{\alpha_s}{\alpha_0} = \frac{2}{b}\frac{\sin u'}{K_t N'_{0s}\lambda}. \qquad (2)$$

Here b is a coefficient close to unity ($b = 1.14$); u', aperture angle from the side of the image space; K_t, the contrast of the test-object; N'_{0s}, the resolving

power of the sensitized layer when $K_t = 1$; λ, the wave-length of the light acting on the layer.

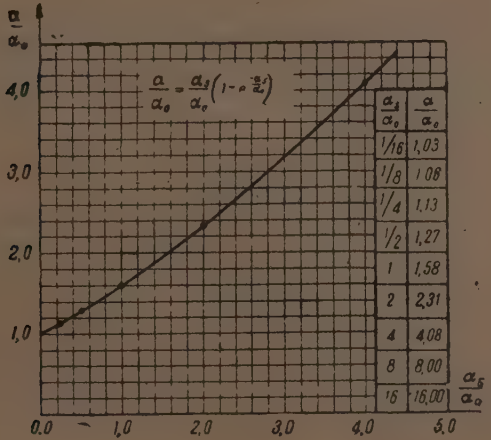
From formulae (1) and (2) follows

$$1.\ \lim \frac{\alpha}{\alpha_0}\Bigg|_{\substack{\alpha_s \to 0 \\ \alpha_0 = \text{const}}} = 1,\ \text{i. e. } \alpha\Bigg|_{\substack{\alpha_s \to 0 \\ \alpha_0 = \text{const}}} = \alpha_0 = \frac{b\lambda}{d\ \cos u'}. \qquad (3)$$

In the expression (3) the value α_0 represents Rayleigh's formula ([2]). Here γ_0 is angular magnification in the pupils; d, the diameter of the exit pupil of the instrument.

With the object plane in an invariable position it is possible for any given value of α_0, by increasing the distance s'_0 from the exit pupil to the image plane, to obtain $\alpha = \alpha_0$ whatever the values of K_t and N'_{0s}.

$$2.\ \lim \frac{\alpha}{\alpha_0}\Bigg|_{\substack{\alpha_s \to \infty \\ \alpha_0}} = \frac{\alpha_s}{\alpha_0},\ \text{i. e. } \alpha\Bigg|_{\substack{\alpha_s \to \infty \\ \alpha_0}} = \alpha_s = \left(K_t N'_{0s} f \left(1 + \frac{\gamma_0}{\gamma}\right)\right)^{-1}. \qquad (4)$$



In the expression (4) the value of α_s follows from the definition of this value, as made above. Here f is the focal distance of the system; γ, angular magnification for the object plane. From the graph and table of the figure it is seen that practically

$$\alpha\Big|_{\frac{\alpha_s}{\alpha_0} \geqslant 4} = \alpha_s,\ \text{i. e. } \alpha\Big|_{\sin u' \geqslant 2 K_t N'_{0s} \lambda} = \alpha_s. \qquad (5)$$

In this case α depends no longer on the diameter of the pupil, and its relation to λ is determined by the dependence of N'_{0s} upon λ. A change of any of the three quantities K_t, N'_{0s}, f can be offset by the inverse change of the other two, such that α should remain invariable [Formula (4)].

As the contrast of the test-object K_t is decreased, other conditions being equal, a value $K_t = \frac{\sin u}{2 N'_{0s} \lambda}$ is eventually arrived at from which onwards we have $\alpha = \alpha_s$ [Formula (5)]. Formula (4) describes the limit of resolution of a photographic instrument for a very wide range of practical cases.

3. In the general case α should be computed by means of formula (1) from which it follows in particular that

$$\alpha|_{\alpha_s-\alpha_0}=1.58\alpha_s=1.58\alpha_v. \tag{6}$$

In the general case $\frac{\alpha}{\alpha_0}$ decreases with $\frac{\alpha_s}{\alpha_0}$, and, when the diameter of the exit pupil and the wave-length are given, is the smaller, the larger the product $s_0'K_tN_{0s}'$.

Formula (1) permits us suitably choose the parameters of a photographic optical instrument.

The image of a given size can be obtained either directly or by using an optical system with a smaller value of f and subsequently magnifying the photograph. In the former case α is smaller than in the latter, as may be concluded from what has been said here.

Throughout this work the nature of the test-object, the photographic process and the conditions of observations are supposed to be identical in determining α and α_s. The values of α are optimum values.

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TECHNICAL PHYSICS

INTEGRATION OF LIGHT ON SPECTROGRAPHIC ANALYSIS

By J. S. SEDOV

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For the excitation of the spectrum in spectrographic analyses one is compelled to the use of such light sources that give no uniform or continuous radiation (spark, arc).

Much has been done to improve this state of affairs, and by now a number of sources with greatly increased stability of radiation (Feisner's spark, air blowing of the spark gap, alternating current arc and others) are placed at the disposal of the spectrographic analyst. None the less he is not yet in a position to obtain his estimations from the measurement of the absolute blackening of spectral lines pertaining to the element under analysis, and has to resort to the so-called «inner standard» method proposed by Gerlach. The same cause appears to bar the progress of methods based on an immediate photometrical measurement of spectral lines. From this, naturally, arises the necessity to invent indicators that would permit directly to measure and dose the requisite quantity of light energy.

In literature we find a number of works discussing this subject. Some of them undoubtedly deserve our attention. Köller (1), for instance, has proposed a very ingenious device whereby a photocell and a hydrogen voltmeter are made use of in measuring the amount of light. How much light has been caught by the photocell is indicated by the quantity of liberated hydrogen. Teegan and Rendall (2) have applied a similar principle. But theirs is a copper voltmeter and, accordingly, it is the amount of deposited copper that brings here out the amount of light. With an illumination of 500 luxes 8.8×10^{-10} g of copper is separated in a second. In a book by Mi-Moro-Ano is described a method whereby the amount of light is measured by means of a vacuum photocell and a ballistic galvanometer. This was previousy used by Null (3) for measuring the opening time of photographic shutters. Another scheme proposed by Moskvin (4) includes, besides the photocell, an electric motor or a static string voltmeter of Wulf.

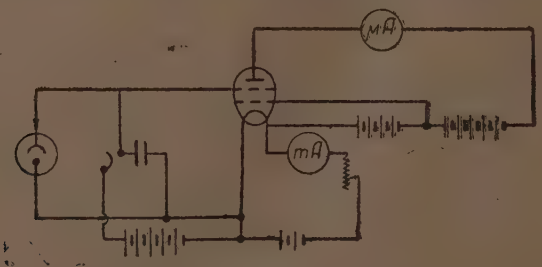
Among the suggested schemes some are built upon a somewhat different principle. Thus, in the scheme of Rentschler (5) the amount of light is determined from the number of discharges. It contains a photoc ll, a condensator, an ionic relay and an electromagnetic relay. In the apparatus of Pull (6) which works on similar lines, the relays are replaced by a neon tube. From the number of its flashes the amount of light is estimated. An analogous device suggested by Khalfin (7) includes a telephone. The number of snaps heard in that telephone indicates the amount of light.

Mention should also be made of several exposure meters manufactured by photographic firms. They are known to fall into two types. Some are based on photochemical action and the others have photocells.

In the first type the time of exposure required is found from the blackening or staining of a light-sensitive plate illuminated by the light in which the photographs are to be taken. To the second type belong devices known by the names of limutron, visomat and illumetre. All of them are based on the luxometrical principle, i. e. on measuring the illumination. Here the suitable time of exposure is determined from the illumination intensity.

Great as is the number of apparatus designed to measure the amount of light energy, no one of them has received a wide application in the domain of scientific photography or in the study of photochemical reactions.

This situation seems to justify the attempts of the author to design the apparatus described in the present paper. By means of it it is possible to integrate and dose the quantity of light. From some preliminary data reported here we can evaluate its fitness to the purposes of the spectrographic analysis. The light integrator built by the author belongs in the class of photoelectric devices. Its scheme is shown in the adjoined figure. As is seen from the latter, the integration of light proceeds as follows. A condenser connected in parallel with a photocell



is charged to a certain voltage from a dry battery by means of a push-button appliance. The voltage is calculated to close the emission current, when applied from the negative pole to the control grid of a cathode-ray tube. Thereby the needle of a microampermeter inserted into the anodic circuit takes the zero position on the dial.

When light is made to act on the photocell, its resistance lessens in time according to the intensity fluctuations. So the condenser gradually loses its charge, bringing about a reduction of the negative voltage upon the grid of the cathode-ray tube. In that case the increase of the emission current within the rectilinear portion of the characteristic curve of the tube is proportional to the amount of light energy.

The device includes an RCA vacuum photocell, type 868; a condenser of Trevou with a 2 μF capacity, 1400 volts; and a cathode-ray tube of the CI-2 type. The photocell is inclosed in a light-proof casing having a telescopic tube with a lens and an iris diaphragm. It is set for work at a constant distance from the light source. With the aid of the iris diaphragm; taking also into account the time of exposure corresponding to the kind of photographic plate used, one has to select the requisite illumination of the photocell.

While testing the apparatus, I adjusted the photocell along the axis of the external optical system in front of the spectrograph slit at a distance of 100 mm from the source of light. The results obtained by taking spectrographic records with this device are described below. Several spectrograms have been taken from a single specimen of a chromium-nickel steel on a single plate. Two condensed sparks were used as luminous sources: one from a transformer, 200 voltamperes, 18 000 volts; and another, with 500 voltamperes, 14 000 volts. There was no additional self-induction in either case. With each of these sources 6 spectrograms were taken. 3 out of this number with an air-blowing of the spark gap through the central opening of the upper electrode(2) and the other 3 without air blowing the spark gap. In all cases the gap was adjusted to a width of 3.5 mm.

The amount of light equal in all records was dosed from the readings of the microampermeter, and at the same time there was registered the actual time of exposure.

The photometrical measurements of the spectrograms yielded the data tabulated here.

Number of spectrograms	Reading of microampermeter	Actual time of exposure	Blackening of spectral line Fe	Blackening of the background about the line	Blackening difference	Conditions of excitation
1	20—80	11 min. 30 sec.	0.345	0.10	0.245	Transformer 200 VA, 18000 V, capacity 0.035 μF, without air-blowing
2	20—80	8 » 15 »	0.355	0.095	0.26	
3	20—80	8 » 55 »	0.32	0.07	0.25	
1	20—80	— 30 sec.	0.41	0.16	0.25	Do, with air-blowing
2	20—80	— 39 »	0.425	0.18	0.245	
3	20—80	— 40 »	0.46	0.185	0.275	
1	20—80	— 27 sec.	0.335	0.08	0.255	Transformer 500 VA, 14000 V, capacity 0.01 μF, without air-blowing
2	20—80	— 30 »	0.33	0.10	0.23	
3	20—80	— 26 »	0.32	0.08	0.24	
1	20—80	— 27 sec.	0.33	0.09	0.24	Do, with air-blowing
2	20—80	— 28 »	0.32	0.10	0.22	
3	20—80	— 27 »	0.33	0.10	0.23	

From the table the following conclusions can be drawn.

In spite of differences between the light sources used, as to their intensity and electrical data, the actual time of exposure varying within a very wide range we can yet be sure to obtain sufficiently equal blackenings with the help of the light integrator described.

But so widely different light sources are not generally used for separate spectrographic determinations. Therefore there is every reason to expect that the use of the light integrator will increase the accuracy of spectrographic analyses and make it possible to base the determination of impurities upon the absolute blackening of the respective spectral lines.

An apparatus built on that principle is also likely to be of value; when the method of direct photometrical measurement of spectral lines is applied.

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CHEMISTRY

MICROCINEMATOGRAPHIC INVESTIGATION OF THE PROCESSES OF CRYSTALLIZATION OF NITRATES

By S. I. WOLFKOVICH, Corresponding Member of the Academy, and T. V. GLASOVA

Ammonium, potassium, sodium and calcium nitrates have been studied microcinematographically in connexion with an investigation of certain physical and physical-chemical properties of these salts. The changes have been studied which took place with the crystalline structure of the salts upon a heated stage of a microscope in the natural or polarized light.

The processes of initiation and growth of the crystals of the salts from the saturated solutions of crystallization of the molten samples, as well as those of change of crystals from one modification to another, of the formation of clusters and druses or of the effect of certain crystals upon each other, have been registered on a film at a rate of 64 pictures per second. At the same time the size of the crystals and their rate of transition from one modification to another (in seconds) have been recorded. Monocrystals as well as the crystalline masses have been studied in mono- and binocular microscopes in a reflected light at a magnification from 60 to 600 times.

The conformity of the actual temperature of the salt upon the heating stage of the microscope to the readings of the thermocouple has been tested on the common low-melting organic substances; the difference in the results was within 1°C. The transition temperatures for the change of one crystalline modification of a nitrate to another have been measured moreover by N. S. Kurnakov's pyrometer. The structure of some crystals of ammonium nitrate has also been studied by means of X-rays.

Besides the investigation of the structure of the salts, we have studied certain physical and physical-chemical properties of the nitrates having practical importance: volume, specific gravity, compactness, coalescence and hygroscopicity (by N. E. Pestov's method). Furthermore, a series of laboratory tests has been carried out on crystallization of ammonium nitrate under various conditions of cooling of the molten sample or the saturated solution similar to those occurring in industrial apparatus. The purpose of these tests was to examine the conditions necessary for preparing the crystals of a given size and form, and having a minimum coalescence and hygroscopicity.

Here are the main results.

1. In addition to the five stable polymorphous modifications of ammonium nitrate available in reference books whose transition points are 125, 84.5, 32.5 and —16°C, and to the modifications stable only at increased pressures, one more transition point at the least is recorded by microcinematography at a normal pressure and within a temperature range of 44 to 57° C.

2. Contrary to literary data, the transformation of ammonium nitrate crystals from the regular to rhombohedral system on cooling the molten sample down

to 125° is accompanied by the contraction of volume. The transformation to α-rhombohedral form at 84.5° is accompanied by increase of volume, and that at 32.5° by contraction of volume. The bulk of samples of ammonium nitrate prepared at 125, 70 and 0° with particle size ranging from 0.5 to 1 mm were 0.77, 0.86 and 0.92, respectively.

3. Ammonium nitrate that had been crystallized at 0° had compact structure, with solid vitreous surface, the mass splitting when struck into fragments having crystalline structure with a particle size of 100 to 400 microns. The crystalline mass obtained at 70° had no such dense and hard surface as that obtained at 0 to 20°, and split in response to a blow into clusters and separate crystals from 10 to 30 microns in size. This structure remains unaltered after the mass had been cooled down to 40—20°. This is the reason why ammonium nitrate obtained at 70 to 40° is more hygroscopic and coalescent than that prepared at 0 to 20°. Ammonium nitrate obtained by rapid cooling of the molten sample down to 20—0° is almost incapable of coalescence.

4. Microcinematographic study of the crystallization of potassium nitrate from its saturated solutions recorded a transition of crystals from a rhombic modification (with almost quadratic cross-sections) to a rhombohedral one (elongated form) when the sharp apexes or facets of the latter are brought into contact with the former. First, the surface of the rhombic crystals is rapidly transformed, and then they disintegrate to a mass of small crystals which give rise to elongated crystals of the rhombohedral form. The influence of the latter is not confined to the crystals in immediate contact, but those in the neighbourhood and even some of the rather distant ones are also affected.

5. The size of the crystals of anhydrous calcium nitrate was almost independent of the temperature of crystallization of the molten sample. Calcium nitrate crystals obtained at 0 to 20° did not coalesce; they coalesced at higher temperatures. Sodium nitrate behaved in about the same way. It was less coalescent than calcium nitrate. Potassium nitrate obtained at 0 to 40° did not practically coalesce.

6. The film has also recorded the crystalline structure of the salts (ammonium nitrate, for the most part) as affected by the rate of heating and cooling, and the duration of separate stages of the process of crystallization and recrystallization. The effects of stirring the solutions or keeping them undisturbed have been registered too along with the action of various crystalline modifications upon each other. The transformation of one crystalline form into another is marked under the microscope by instantaneous appearance of some foggy veil which conceals the details of the process.

The microcinematographic filming has been carried out by the authors at the Photo-Cinematographic Laboratory, Academy of Sciences of the USSR, and all the other studies performed at the Laboratory of Salt, Samoilov Scientific Institute for Fertilizers and Insectofungicides. Valuable assistance has been received from G. B. Ravich and V. A. Volnova.

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GEOCHEMISTRY

ON THE ORIGIN OF CEMENT IN THE OIL-BEARING HORIZONS OF KRASNOKAMSK

By L. V. KHMELEVSKAYA

(Communicated by S. S. Nametkin, Member of the Academy, 28. VII. 1943)

In the present note use was made of the material included by the author in the report of the staff of the Petroleum Prospecting Institute, whose aim it was to work out fundamentals for an adequate operation of the Krasnokamsk deposit.

When studying the cores from the oil-bearing horizons of Martyan in wells Nos. 15, 17, 36, 41, 45 and 50 the following method has been adopted. The exposed thin-sections were coloured with an aqueous solution of safranin. Upon drying, the thin-section was covered with a cover-glass, under which a drop of immersion liquid was introduced whose index approached that of Canada balsam. The dye contributed to a more distinct visibility of the capillaries, pores, cracks, and made it possible to establish the presence of a clayey admixture. Pure crystalline limestones did not absorb the dye. The latter was regularly deposited all over the surface of the thin-section, imparting to it a slight pink hue. If capillaries were present, the latter would absorb the dyestuff and became distinctly visible. Pure micrograined and clot-like limestones also took on an even coloration, but if it was an admixture of clayey material, clots would absorb the dye and become bright-red, sharply distinguishing against the field of the thin-section.

The presence of bitumens was determined by the method of test-tubes.

The porosity in the specimens was determined after extracting the bitumens by the method of soaking with kerosene. The permeability was studied by the method of V. F. Zhuravlev. A detailed comparison of thin-sections prepared of the same rocks, but of specimens possessing a different value of porosity, invariably permitted to find out the causes underlying the differences in the porosity value. These could be reduced to relations between the cementing mass and the groundmass of the rock, the size of the cement grains, the presence of clayey admixture, and the composition of the groundmass of the rock.

In rocks of different names the porosity value is related to the origin of the pore spaces and of the cement. The pore spaces in the specimens investigated could be classed according to their origin into primary and secondary ones. To the primary are referred voids in cells of *Foraminifera*, bryozoans, and voids in the remains of skeletons of other animals and algae, capillaries and small cracks in detritus and slime. To the secondary are referred supracapillary, capillary and subcapillary spaces between the grains of the carbonate cement, as well as the «porosity» caused by the sorption properties of the minerals of the clayey admixture.

The appearance of cement prevents the communication between the pores. The secondary porosity which is of the greatest value for reservoir beds, depends on the structure of the cement and on its development. In the material examined some stages in the development of the cement may be traced.

I stage. A cementation of clots of micrograined and detrital silt which started at the time of lithogenesis. All the voids of organogenous fragments, cells of *Foraminifera* devoid of organic content, were filled with carbonate in the form of grains about 0.01 mm in size and smaller. The cement which had been formed during the first stage of development (primary cement) was observed in the oil-bearing horizons II, III; IV and in some wells in horizon V (wells 15, 17 and partly 36) of the Martyan deposit.

II stage. Dissolution of the cement of the I stage.

III stage. The voids formed during the II stage are filled with secondary cement, in the form of grains of carbonates or silica larger than those of the cement of the I stage. On the walls of the pores remains of cement of the I stage are to be seen. The central part of the pores is filled with secondary cement. A development of secondary cement was observed in the Vb and VII oil-bearing horizons, and partly in IV and Va.

The limestones with primary cement are impervious to oil under laboratory experimental conditions. Yet, they are porous and contain oil. Their being impervious, on the one hand, and porous and oil-bearings, on the other, may be due to the presence of organic matter (remains of plants) from which oil was formed in the calcareous silt previous to its cementation. Filling up a certain volume, the organic matter prevented a complete cementation of the rock.

The dissolution of the primary cement of the I stage might have taken place by way of circulation of the underground waters by which the carbonate was carried away (II stage). The secondary cement might have crystallized out according as the solutions would become stationary instead of circulating ones (III stage). At this time filling of the *Foraminifera* cells took place, as well as formation of incrustations and filling up of the pores formed owing to the dissolution of primary cement. Two possible cases of setting in of the circulation of underground waters may be imagined.

1. The tectonic movement proceeded upward. A shifting of the water-bearing stream causing the dissolution of cement of the I stage proceeded in downward direction with respect to the original position of strata. The second stage of development underwent those strata which were situated in the interval between the original position of the ground water level and the newly formed underground base-level of erosion. The oil contained in this interval together with the water might have been entrained to the new base-level. The beds which lay above the initial level of the aquiferous stratum remained at the I stage of development of cement, the organic matter which had found way there before the cementation being preserved. Upon a new rise of the base-level of erosion the oil which floated over the rising water layer, could have found way to the pores produced. Equilibrium being attained, the pores were filled anew with carbonate of the III stage of development, plugging the oil carried into the pores.

2. The tectonic movement proceeded downwards. The base-level of erosion was rising. The aquiferous horizon was shifting upward with respect to the strata, entraining the floating oil. The strata lying between the original level of the aquiferous horizon and the newly formed one were freed from oil, and the pores originally occupied with oil were filled with secondary cement.

The material here exposed refers to the first case.

The influence of the moving water stream is seen in the cement of the V and VII and partly IV oil-bearing horizons. The cement of the first stage is preserved in the II, III and partly in the V oil-bearing horizons.

Conclusions. 1. The least permeability is shown by the oil-bearing limestones and dolomites of the III and IV horizons, having primary cement.

2. The most permeable are the oil-bearing limestones with secondary cement.

3. The most readily operated are the oils contained in strata with secondary cement, the latter being more permeable.

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GEOLOGY

ON THE RED DEPOSITS OF THE «RED BED» TYPE IN THE PERMIAN DEPOSITS OF THE MIDDLE VOLGA AND NEAR-KAMA REGIONS AND ON THEIR COLOUR

By L. M. MIROPOLSKY

(Communicated by V. G. Chlopin, Member of the Academy, 1. VI. 1943)

Out of the Permian deposits the author classes among the red-coloured deposits of the «Red Bed» type those of the Ufa and Belebeyev series; and the Tartar stage. Within the territory of the Middle Volga and the Lower Kama region they are represented by a variegated complex of alternating clastic and carbonate rocks.

Among these, along with normal varieties of sandstones, aleurolites, argillites, dolomites and limestones, there is observed a wide range of intermediate, transitional rocks. In many cases the separation and characterizing of the rocks is prevented by the presence of micro-lamination due to a combination and interlacing of several types, and occasionally by the absence of a distinct demarcation between the rocks belonging to different strata.

The distribution of rocks according to separate stratigraphical units in different exposures and regions, is therefore hardly comparable. This is mainly caused by non-uniformity of thicknesses, variation of the lithological aspect of the rocks, presence of pinching-out and replacement of some rocks by others, variability of structural and textural peculiarities, and the state of preservation and coloration even in rocks of the same type.

The distribution of and the part taken by different types of rocks in the profile of the said deposits, according to the best studied exposures, are shown in the table.

From a review of the table and a number of other exposures the following peculiarities should be noted: 1) a predominance of clastic rocks in the Ufa and Belebeyev series and an increase of carbonate rocks in Tartar stage; 2) a complicated inter-bedding of different types of rocks with their frequent alternation along the profile; 3) variable sequence of stratification of the rocks in the vertical section; 4) lack of constancy in the composition of subordinate components; 5) variable manifestation of secondary and later phenomena; 6) diversity of the quantitative distribution of secondary segregations of minerals, and a number of other features.

At the same time the nature of stratification points, on the one hand, to variable conditions of sedimentation and occasionally even to a very rapid facial variation owing to a sharp change of sediments, and on the other hand, to a periodical rhythmic, discontinuous supply of matter to the bottom of water basins.

With all these peculiarities, the deposits of the Ufa and Belebeyev series and of the Tartar stage resemble each other in the following points: 1) an exten-

Deposit	Locality of exposure	Thickness in m	Number of beds	Distribution of rocks according to thickness, %						
				Limestones	Dolomites	Marls	Argillites (clays)	Aleurolites	Sandstones	Conglomerates
Tartar stage (P_2^{tat})	Right bank of the Volga at vill. Vodoleyevo-Demeshkino	67	160	31*	31*	6	18	8	6	—
Belebeyev series ($P_2^{kaz_2}$)	Right bank of the Kama at village Sentyak	102	54	2	—	0.5	61.5	5	28	3
Ufa series (P_1^{uf})	Right bank of the Kama at town Elabuga	35 (apparent)	35	—	—	—	31	9	58	2

* In a number of cases marlaceous, and of pinkish and other colours.

sive development of rocks of the clastic series; 2) a prevailing reddish-brown coloration of the rocks; 3) a frequent alternation of rocks along the vertical profile; 4) a spatial variability with persistent phenomena of pinching-out and replacement of some rocks by others; 5) a poor development of fauna; 6) a small extent of grading of terrigenous material according to size and rounding; 7) similarity of the mineral composition in the main types of rocks; 8) uniformity in the trend of the process of rock alternation; 9) prevalence in the composition of secondary segregations of leading elements of the carbonate and hydrate forms of compounds.

The analysis of the lithology of the deposits has shown that the variegated nature of their lithological composition and coloration cannot be ascribed to primary processes of their formation alone. Among them in some intercalations the transformation of rocks in the course of weathering into rocks of a different type, and colour variation in the course of these processes are clearly observed.

The first fact was noted by the author as early as in 1929 when studying the deposits of the Tartar stage in Chuvashia (1). Later on B. P. Krotov raised it to the rank of an universal principle, terming the deposits of the Tartar stage «the weathering crust» (2). The facts of transformation of primary rocks into derivatives of a different type in individual intercalations may be traced over the territory of the Middle Volga and Near-Kama regions not only in the deposits of the Tartar stage, but among the Belebeyev and Ufa series as well. Irrespective of the age of the deposits and the locality of occurrence, the processes of transformation of primary rocks generally follow a similar course. Dolomites, calcareous dolomites and dolomite limestones pass first into marlaceous carbonate rocks, then into marls and, finally, to marlaceous clays; aleurolites—to aleurites; sandstones—to sands; conglomerates—to pebblestones.

This is based on two phenomena: 1) removal from the rocks by way of leaching-out of carbonate and other readily soluble components (process of decarbonization), and 2) an enrichment of their transformation products with insoluble and sparingly soluble components (process of silting). The rocks transformed show the following features: increase in porosity, appearance of rotting, looseness; occasional persistence of textural and structural features, with a varying degree of disturbance, viz. of perforated habit in the transformation products of carbonate rocks, «consanguinity» in the composition of terrigenous components,

presence of relicts of original rocks with various degrees of alteration, increase of colloidal material.

The above facts of alteration of rocks from the deposits of the Tartar stage have earlier been described by the author ([1],[3-4]); in the recent years they were subjected to supplementary study near the town of Maryisky posad. Similar facts have been traced by the author in the course of a study of the lithology of the deposits of the Belebeyev and Ufa series on the Kama river. In particular at the village of Kamskie Polyany at «Kamensky Log» among the deposits of the Belebeyev series, dolomitic limestones were found to transform into marls, and sandstones into loose sands. The same was observed in some intercalations near the Sentyak village. The transformation of aleurolites into friable aleurites, of sandstones into sands, of marlaceous clays into clays, was traced along individual bands, and among the deposits of the Ufa series in the exposures near the town of Elabuga, the village of Tikhiye Gory and Izhevsky Istochnik village.

The change in the coloration of a rock is closely related to the process of alteration of its lithological aspect. When it attends the transformation of carbonate rocks, the following sequence of colours is usually observed: grey in unaltered rocks, greenish-grey and pinkish in the intermediate members, and red-brown or yellow-brown in end members; in clastic rocks: grey or greenish-grey—yellowish-grey—yellowish-brown or reddish-brown, respectively. The process of colour variation in rocks is fully concordant with the course of rock transformation.

Among the various types of rock transformation and of change in their colour, the following three main types may be distinguished: 1) lit-par-lit, 2) spotted, and 3) stream-like.

In the first case the transformation of the rock proceeds in a layer, either on its surface, or along the base, or simultaneously on both sides. Accordingly, the change of coloration takes place. Such a type of the rock transformation and of colour was observed by the author among the deposits of the Tartar stage in the carbonate rocks near the villages of Krasnovidovo, Syukeyevo, Vodoleyevo and at several other places, and within the Belebeyev series, near the villages of Kamskie Polyany, Sentyak, and in other regions.

In the second case, the transformation proceeds within a layer in a selective way, mainly by spots. Such a type of rock transformation and of its colour variation was observed by the author in the deposits of the Tartar stage at the town of Elabuga, the Tikhiye Gory village, and at several other places.

In the third case the process is observed to develop in layers along distinctly pronounced channel-ways of migration of ground waters. Along them, e. g. along small cracks, pathes etc.; the carbonate rocks become more porous, sometimes loose and more marlaceous, and accordingly the coloration is changed to light-green, then to greenish or pinkish, and even to reddish-brown. The same is observed also for aleurolites, sandstones, etc.

What is then the reason underlying the change in the coloration of the rocks of the Ufa and Belebeyev series, and the Tartar stage? A. E. Fersman ([5]) has already suggested a solution of the general problems of appearance of colours, and of the one we are dealing with here, in particular. It seems to the author that the appearance of coloration in the cases discussed should be considered a secondary phenomenon. It is caused in the first place by a change in the state of the chromophore elements, mainly of iron and possibly some others, to a lesser extent of manganese. In original rocks of less intense coloration, iron and manganese are present in the ferrous and manganous forms in the first place in clayey material, probably in nontronite, Fe-montmorillonite; allophanoid clayey material, occasionally in pyrite and terrigenous material. In the case of altered aeration conditions the chromophore elements, iron and manganese, passed to higher oxidation forms. In individual bands it is observed in the first place along distinctly pronounced cracks, pores, holes and occasionally along hidden supercapillary channel-ways, the whole rock or a part of it being gradually involved in the process.

The degree of hydration of the oxides, a different quantitative content of chromophore elements, as well as the ratio of their oxides, are responsible for the appearance of a given shade, mainly of rusty-brown.

The above data are far from exhausting the whole variety of the changes of carbonate and clastic rocks observed among Permian red deposits. There are places where processes of a quite opposite nature may be observed, e. g. secondary calcitization of the rocks, with a subsequent variation of rust-brown colorations to greenish and greenish-grey in water-impervious bands and over them.

The phenomena described throw light to only one side of the actual variety of the lithology and of coloration, which can by no means be accounted for only from the standpoint of facial changes. The degree of variation among red deposits depends on a number of causes, such as the depth of their occurrence, nature of the overlying and underlying rocks, permeability and arrangement of ground waters, structural and textural features, composition, in particular, on the presence of organic substances and sulphide compounds and chiefly on the extent of drainage and aeration.

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PHYSIOLOGY

ON THE DIFFERENCE IN RESISTANCE TO COLD AND OTHER INJURIOUS FACTORS IN MALES AND FEMALES OF *DROSOPHILA MELANOGASTER*

By P. G. SVETLOV

(Communicated by L. A. Orbeli, Member of the Academy, 27. IV. 1943)

The very fact of male and female individuals being not equally susceptible to unfavourable life conditions is widely known. Suffice it to recall the data on foetal and infantine mortality in man (Gunther and others), in cattle (Juvell, 1921), in various insects, and apparently in many birds as well. Similar data are available for plants, too. The numerical ratio of sexes within a population is also largely influenced by the different rate of mortality in males and females. As a rule, mortality is higher among the males, although the reverse relation has also been reported, e. g. for *Juniperus communis*.

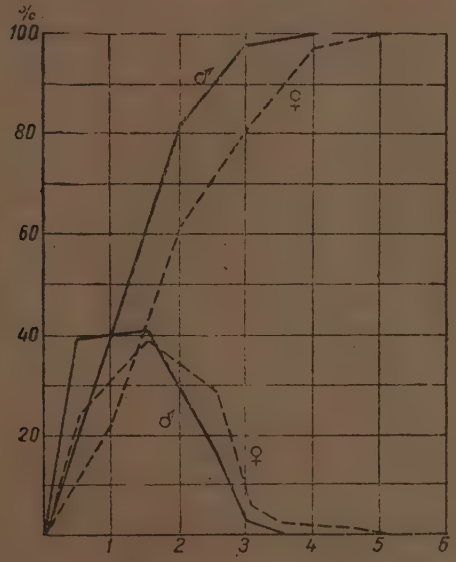
During the tragical events that took place in Leningrad in the winter 1941—42 it became a fact of every-day experience that young vigorous men were almost the first to fall victims to distrophy. Various reasons were advanced to account for this rather paradoxical phenomenon: mention was made of the different mode of life of the two sexes, of the fat deposits in women, of the different relation between body volume and area, etc. These differences have been interpreted in a similar way in animals, viz. stress was laid upon different behaviour, energy expenditure on sexual activity, body dimensions, etc. However, so far as I know this phenomenon has never been the object of special investigation, although it may scarcely be any doubt that we are faced here with an important problem.

The general problem of the susceptibility of organisms to injurious factors has eagerly been discussed for the last decades. An outstanding position in the literature devoted to this subject belongs to works by Ch. Child who found out that: 1) the degree of susceptibility does not depend on the way an organism is acted upon, i. e. when the most various agents are operative, the susceptibility has the same course; 2) the susceptibility increases along with the growth of the «physiological activity», the latter being expressed by the intensity of metabolism; 3) this is why susceptibility usually diminishes with age.

I am inclined to refer these regularities to the g e n e r a l p r i m a r y s u s c e p t i b i l i t y which may be complicated with attendant secondary and specific circumstances. The idea suggests itself that the variation in the resistance in males and females, or as we shall term it in the subsequent, t h e s e x d i f f e r e n c e of s u s c e p t i b i l i t y, may possibly fit within the category of general primary susceptibility which should be supposed to be based upon some peculiarities of the biochemical structure of the protoplasm. If we give this question a positive answer, all other explanations will either be discarded, or will find their respective subordinate places, i. e. will point to the existence of accessory factors superimposed upon the fundamental one discovered by us.

As experimental material I chose *Drosophila melanogaster* which is a cheap and convenient laboratory animal, having well pronounced sex characters. Besides, literature contains data to the effect that the males of *Drosophila* are endowed with a higher rate of metabolism than the females (Paulsen, 1935). The material has been obtained from R. A. Masing who collected the flies at the village Shelanga, near Kazan. The experiments were carried out in the laboratory of Prof. A. N. Mislavsky, at the Kazan Medical Institute. The cultures were kept in a thermostat at 23—26° C, upon a nutrient medium prepared of potato or dried apricots with meal or agar-agar.

Experiments on Starvation. The flies from a single culture were separated under a slight ether anaesthesia into males and females, counted and placed into two empty vials. Small pieces of cotton or strips of filtering paper wetted with water were put in each vial in order to keep them moist. The



Run of dying-out of males and females of *Drosophila melanogaster* subjected to starvation at 25°.

perished flies were then regularly recorded in both vials. Those of them which were found utterly immobile were considered dead. Such flies, when given food, do not come to life again, even under optimal conditions.

The *Drosophila* flies were found to show a very low resistance to starvation: when kept at 25 C, by the end of the third day of the experiment all the males perished; only isolated females survived which also perished towards the end of the fifth day. Under good conditions *Drosophila* flies are known to live for months.

The results of the experiments carried out in a thermostat at 25°C are represented in the figure. The run of the dying-out curves shows that the number of dead males (in per cent) per day invariably exceeds that of females. The percentage of males and females perished in the course of 24 hours is also plotted on this graph.

The sex difference of susceptibility is best of all illustrated by the figures of the mean longevity, derived from data on the number of flies dying per one day of experiment. The curves that illustrate the dying-out of the flies within a 24-hour day represent the frequency distribution, its centres corresponding to the mean lifetime. The mean quadratic errors proved so small as compared

to the difference of the means that there was unnecessary to compute the error of difference.

Similar experiments were carried out at temperatures of 12—16° and 4—7° C. The sex difference is especially well pronounced with 12—16° C: in some of the experiments a large majority of males perished, whereas nearly all females survived. For lack of space I give here instead of numerical data for the separate experiments data summarized for three experimental runs only.

Table 1

Temperature	Number of experiments	Number of flies under experiment		Maximum lifetime		Medium lifetime		Standard deviation of the means
		♂	♀	♂	♀	♂	♀	
25°	15	640	696	3.5	4.5	1.78 ± 0.03	2.26 ± 0.03	0.48
12—16°	12	454	493	5.5	7.0	1.69 ± 0.04	3.20 ± 0.06	1.51
4—7°	4	234	210	10	12	3.98 ± 0.09	5.02 ± 0.09	1.02

Some of the experiments yielded results that were near to the negative: both males and females perished very soon. These results are, however, quite consistent. Such a course is typical of experiments carried out on material from overpopulated cultures, offering poor life and development conditions. Flies from overpopulated and old cultures are less resistant, and their sex difference of susceptibility is less sharply expressed; nevertheless. it is preserved and has the same sign as in flies from vigorous cultures. It has also been found that age variation within one month plays no essential rôle in the magnitude of the sex difference of susceptibility.

Effect of Cold. Four experiments were carried out involving 182 males and 206 females. The flies were kept at 4—7° C in vials on normal food. Under these conditions the flies subjected to cold-treatment lived much longer than under starvation regime at similar temperatures. The maximum longevity for males and females was found to be 14 and 19 days, respectively. The mean lifetime for the males is 9.42 ± 0.08, for females it is 10.01 ± 0.16 days. In order to estimate the significance of the difference of the means, the error of difference was computed and found to be $m_{\text{diff}} = \sqrt{(0.08)^2 + (0.16)^2} = 0.19$. Consequently, $\frac{\text{Diff}}{m_{\text{diff}}} = 3.10$, thus, the difference between the means of longevity in favour of the females has been found statistically significant in this case, too, although in our cold-resistance experiments the means are nearer to one another than in the starvation experiments. As to the difference between the maximum longevity in males and females it is much greater in the case of low temperatures than with starvation.

Effect of Vapours of Various Substances. The experiments involved treatment with vapour of ether, alcohol and formalin. The flies were subjected to the influence of those substances in vials supplied with ground stoppers; to the cover there was suspended from within by means of a thread a small piece of cotton soaked in a definite number of drops of the substance to be tested. The time of exposure was so chosen as to have about a half of the flies perished. Directly upon the treatment the flies were found to be motionless. Males and females were picked out, counted and placed into different vials. After a certain time, when the flies that had survived became mobile again, the number of dead males and females was computed. The results are summed up in Table 2.

The figures of this table leave no doubt as to the higher resistance of females to the lethal effect of the substances tested.

The effect of each of the factors tested is distinguished by some specific features: so, for instance, low temperatures are characterized by the flies resisting to

Table 2

Substance tested	Number of experiments	t, °C	Exposure in minutes	Number of flies per experiment		Survived			
						Number of flies		In per cent	
				♂	♀	♂	♀	♂	♀
Ether . . .	3	14	7	164	163	59	86	35.46	52.76
Alcohol . .	3	14	30—50	165	163	45	69	27.27	42.33
Formalin .	2	14—25	10—50	151	152	27	68	11.15	44.73
Total . . .	8			480	478	131	223	27.29± 0.83	46.23± 2.28

their effect during a long period; owing to which the curve of mortality of the flies in the culture assumes a symmetrical S-like shape. Formalin is distinguished by the phenomena it brings about: the flies are ill during a long period of time and move about with difficulty. But whatever the kind of affection, the relation between the resistance in males and females remains constant.

The experiments described above permit of the following conclusions: 1) Females of *Drosophila melanogaster* are more resistant than the males to the effect of starvation, low temperature, and vapour of ether, alcohol and formalin. 2) Resistance to starvation belongs to the complex of resistance to unfavourable factors in general. 3) The sex difference of susceptibility is based on a difference in the primary general susceptibility.

In order to substantiate the latter conclusion it should be found out in the first line, what is the way in which the sex difference of susceptibility is manifested in the ontogeny.

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MICROBIOLOGY

PURIFIED PROTEIN PREPARATION FROM THE VIRUS OF OAT MOSAIC (ZAKUKLIVANIE)

By K. S. SUKHOV, A. M. VOVK and T. S. ALEXEEVA

(Communicated by L. A. Orbeli, Member of the Academy, 27. IV. 1943)

In 1937 numerous needle-like inclusions were discovered by Sukhov in the cells of oats affected with zakuklivanie. Later he also found such cells to contain inclusions of more complicated shape, in the form of rings or loops ([1], [3]). From the evidence furnished by microchemical reactions these inclusions appeared to consist of a protein substance. Their strict specificity in relation to the above-mentioned disease was proved on a vast material and their protein was just supposed to be the virus of zakuklivanie. The probability of this assumption increased strongly after the same author had found that the insect *Delphax striatella*; when put on an affected oat plant, could be observed 6 hours after to contain similar needle-like inclusions in its intestine([3]). Later on the specific inclusions were detected in internal organs, for instance, the salivary gland of the insects carrying the virus ([2]).

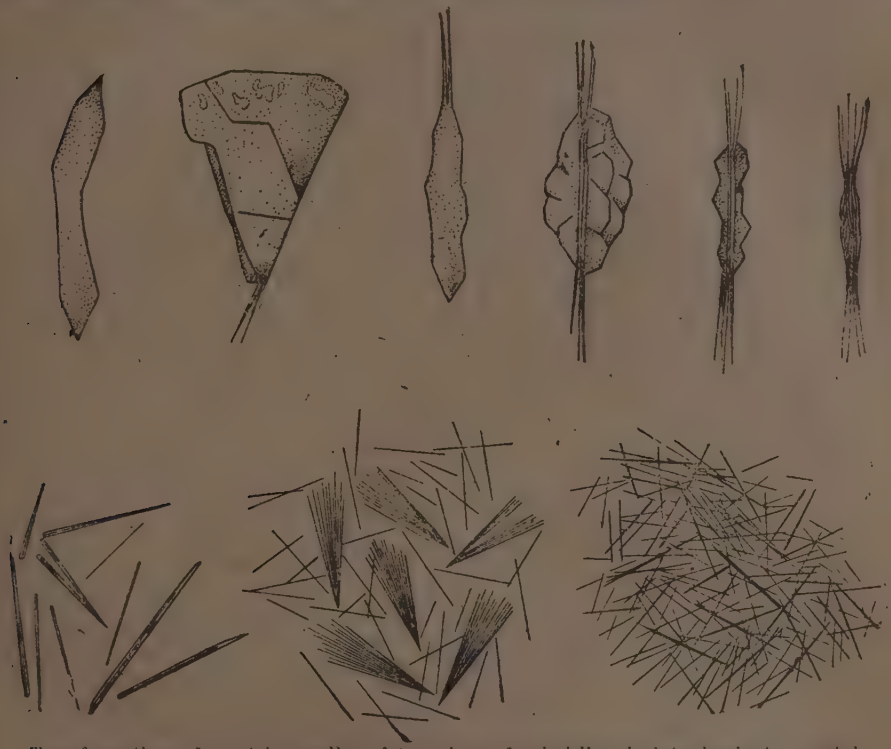
In connexion with these findings there arose the interesting question of the possibility to obtain a purified preparation of the virus of zakuklivanie. In our attempt to secure it we employed the method by which Sukhov in 1941 had purified the virus of winter-wheat mosaic.

Mosaic leaves from affected oats were first cut up by scissors and then ground in a mortar in which a small amount of a 0.1 per cent solution of bicarbonate of sodium had been put preliminarily. The extract obtained was passed through Seitz' filter. To the filtrate decinormal hydrochloric acid was added up to $^1/_3$ of its volume. In pouring in the solution of the acid, care was taken to make it flow down the walls of the test-tube lest it should rapidly mix with the filtrate. Under these conditions a white film of precipitation was formed in several minutes at the site of contact of the two solutions. Its main mass were needle-like crystals with a certain admixture of a granular amorphous precipitate. When the film had reached a thickness of several millimeters, the solutions were mixed by repeatedly shaking the test-tube.

The crystallization, once begun, involved the whole mass of the filtrate, and a profuse turbid suspension composed mainly of needle-like crystals was observed to appear. Upon standing for 24 hours the turbid substance was carried down to form a bulky deposit. It was brown in colour because of the presence of a considerable amount of pigments in the initial extract. Therefore, in order to obtain a purer preparation we used white awns of an affected barley which were deprived of chlorophyll.

In this case, the extraction of the virus and its precipitation with the acid produced a milky-white substance which was all needle-like crystals and con-

tained no granular admixture visible under the microscope. After 24 hours of standing the liquid had its surface layer as colourless as water and perfectly clear. A suspension of these crystals was subjected to biuretic reaction for protein. A clear violet ring was then observed in the test-tube. Thus was brought into evidence the protein nature of the crystals obtained.



Transformation of protein needles of the virus of zakuklivanie into laminate crystals

A separate test was run with extracts from normal green sections of a mosaic leaf, and from leaves altogether untouched by mosaic, taken from bushy dwarfs. The addition of the acid to such an extract resulted in no formation of needle-like crystals. Never these crystals appear in an extract from the leaves of sound oats.

The protein crystals of the virus of zakuklivanie, like those of the wheat mosaic, can be obtained from dry mosaic leaves as well as from fresh. Such preparations we obtained in the extract from leaves preserved in a dry state for 7 months.

So our method of purifying the protein virus is to extract it in a slightly alkaline solution with subsequent precipitation at an acid pH (pH$\sim$5). Shifting the pH to a more acid or more alkaline side brings about a rapid solution of the crystals.

In our experiments on the crystallization of the virus protein some unallowed-for fluctuations of pH should certainly have taken place. This accounts probably for occasional changes in the morphological picture of the crystallization. As a rule, the hydrochloric acid precipitates individual protein needles from the solution. But in some cases aggregates of crystals in the form of a bundle of needles diverging from a common centre are observed in addition. In one of the test-tubes with such crystals, after it had been allowed to stand for 2 weeks, further modifications of the crystals' morphology became apparent. The needle bundles were much denser along their longitudinal axis, and many of them had

their central portion recrystallized into thin laminae approaching in form to the hexagonal system (see figure).

Under the microscope all kind of transition from the start of this recrystallization to its completion was to be seen. In the latter case the entire substance of the densified needle bundles was transformed into large foliated plates. In shape they were irregular polygones whose one or two angles were formed by separate pointed vertices which marked out the ends of what had formerly been a bundle of needles. These vertices not infrequently terminated into a long filament reminding of that of *Flagellata*.

Finally, there were also plates on which no trace of the initial structure of the bundles was visible. Both the individual needles and their aggregates are birefringent. Strong birefringence was earlier observed by Sukhov in crystals found in the intestine of *Delphax striatella* fed on affected oats.

On determining the temperature conditions for the denaturation of the virus protein it was found that keeping the fragments of mosaic leaves for 20 min. at 50° C or 10 min. at 60 C results in an irreversible coagulation of the protein. No virus can be extracted and crystallized from the leaf sections so treated. Even if not the leaves are heated, but their extract in a soda solution, which form no appreciable deposit on heating, still no crystallization of the virus occur in response to the addition of the acid.

It will be apparent that the agent of the disease is to be classed with the viruses unstable to the action of rather moderate temperatures. The purified virus preparation coagulates also when freezed to the formation of ice.

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HYDROBIOLOGY

A PLAIN RIVER SUBDIVISION INTO GEOMORPHOLOGICAL AND BIOLOGICAL DISTRICTS ON THE BASIS OF ITS STRUCTURAL AND BIOLOGICAL UNITY

By D. A. LASTOCHKIN

(Communicated by L. A. Orbeli, Member of the Academy, 30. IV. 1943)

The deep portion of the meander of a large plain river is characterized not only by such features as distinguish it from the shallow portion (depth, alternating periods of deposition and erosion of river load, directions of the dynamic axis, biocoenoses in the district of this axis), but also by those features the two elements of the river have in common, which create their structural unity: by a common type of structure (a ripple mark of the deep and shallow stretch as a whole), unity of some grounds and biocoenoses, a typical transversal asymmetry in the arrangement of grounds, depths, isotachs, loads and benthal biocoenoses.

Forming a morphological couple, the deep and the shallow stretches of the meander are indissolubly linked together; they therefore change conjointly all along the river. According to some hydrologists (Losievsky, Kustov), the shallow portion of the river (river bar, river shoal) is nothing else than a regular development of one of the ripple marks of the sandy convex bank (sandy beach of slip-off bank), taking place with definite current velocities and definite amounts of alluvia carried along with the stream. The joint variation of deep and shallow river portions and to a certain extent of the valley slopes, too, becomes evident from their comparative investigation throughout the river's length (as an example may serve the tributaries of the Volga river).

1. The first district of the river head of a plain river represents a streamlet in a V-shaped valley (Kerbthal of the German writers) with a poorly expressed lateral erosion of the flou, and insignificant depths; the alternation of deep channels and shallows is scarcely noticeable. The flow here is fully static, and may dry entirely.

2. The second district of the river head begins at the point where there appears a slightly developed valley whose slopes are not involved in the meandering. The difference between the deep and the shallow stretches of the river becomes more significant: the former present now oval widenings, the so-called «bochags»; with coarse-grained or stony, occasionally silted uniform ground over a transversal profile. The river bar is usually studded with stones and passes gradually into the adjoining deep channel, unless it is represented by rapids. During the dry season the shoals may dry altogether, and the river appears then to be divided into separate oval widenings. Within a meander such deep and shallow stretches are of repeated and disorderly occurrence: the former may appear at the twist of the bend, the latter at its apex. Berthaut (1) was right in terming these meanders superficial ones.

3. This district may be referred to the upper reach. Here the slopes of the valley (Berthaut's «entrenched» meanders) are again involved in meandering. The distinctions between deeps and shallows become somewhat more salient, the river preserves its unity throughout the dry season. The deep channels show two layers of ground (e. g. of coarse sand and gravel). There are several (10—12) deep and shallow stretches within a single meander.

4. The slopes continue to take part in meandering *. Along the convex bank of deep channels small sand beaches appear, owing to which the peculiar features of the river bars (direction of the dynamical axis, the bluff descent in deep channels) become more prominent. In deep channels, as a rule, a third ground layer is differentiated, that of medium-grained sand. The deep and shallow stretches within a meander become much less numerous.

5. The meanders continue to be «incised». The sand beaches, especially at sharp bends, show a few ripple marks, all elements of sandbars become differentiated. The ground system consists now of four — five elements. There are three — four deep stretches per meander.

6. The last district of the upper reach of a large plain river preserves its «incised» meanders, the deep channels attain their full development, back water of sand beaches appear. The number of deep and shallow stretches is reduced to two — three within a meander.

In a developed deep channel the asymmetrical system of grounds corresponds to the nature of the steep bank: if it coincides with the primary bank, the adjoining link will be that of cobble-stone or grit (for banks of moraine nature), of marl, limestone, flagstone, pre-glacial clays (for banks of pre-glacial character). If the concave or undercut bank of the deep stretch of the meander coincides with the flood plain bank, the system of grounds is adjoined by alluvial deposits: clays, clayey sands, etc. The remaining links of the system are pebble, gravel, coarse sand (in extremely deep channels, silted and unsilted), medium grained sand, fine sand (near sand beaches). At the shoals most of the grounds are broken, and in the next meander downstream they appear in an order reverse, according as the shape of the banks changes.

The sandy load of the convex bank, the so-called sand beaches sink under water in their internal part, where a system of various morphological structures are formed: fields of ripple marks and shallow-water flat area. The structure of sand waves or ripple marks consisting of a morphological couple, a wave and a trough, has been described in the Soviet literature by Shamov (3), Belostozky (4) and Kustov (5). It is essential to point out here the regular diversity of the ripple marks throughout the length of the sand beach in its districts near the adjoining shoals and in the central part: according to the degree of projection of the sand wave towards the middle of the river (in the Volga river near Kazan up to 170 m), to the wave-length, ripple and horizontal indices, amplitude of the wave and degree of siltedness connected with the latter. Downstream of the sand bar, the upper sand beach is adjoined by a shallow, gently sloping area without ripple marks (passing into a back-water hollow) which is somewhat silty because of the sluggish flow. The wide occurrence of these formations in the deep waters of the Middle Volga, up to 300 — 500 ripple marks per one sand beach, results in a great variety of the silted biotopes.

The middle and lower reach of a large river may also be subdivided into several districts according to the following indices: appearance of extremely deep channels of the meander (10 — 30 m), where a number of grounds are silted, replacement of «incised» meanders by superficial ones, which brings about a peculiar sequence of grounds, especially in the case of a bilateral flood plain,

* The relation between the slopes of the valley, the valley and the river channel is occasionally made more complicated by the fact that number of European rivers, even in their upper reach, flow in very wide valleys which are often incommensurable with their channels, the meanders becoming superficial. Dokuchaev (2) supposes that these are places where the river was formerly passing through a lake.

the whole of particularities of the delta, etc. This classification still requires, however, preliminary studies.

Aside from the meanders, rectilinear reaches are common enough. According to my data for the Moscow river and the Volga, and to data by Poliakov ([6]) for the Don river, these reaches are built after the type of a deep channel, except for the sand beaches that are here, unlike the drawing by Kandyba ([7]), more or less rudimentary and largely replaced by abrupt, fine-sandy talus. The rectilinear reach is thus no third elementary structure of a river. The presence of deep and shallow stretches of an essentially similar structure all along the river creates the structural unity of the latter.

From what has been said above a number of important conclusions may be drawn by a limnologist. Downstream there is a regular increase in the diversity of biotopes, which proceeds more rapidly within the upper reach, although there it is attended by a parallel disappearance of the old biotopes (stony shoals; growths of macrophytes along the river channel). In the lower reach the biotopes become less numerous because of an increase of levelling silting. Along with this the qualitative diversity of zoobenthos and nekton also increases without diminishing at the approach to the mouth, owing to the penetration into the delta of sea immigrants and passage-fishes. The peculiarity of the density variation of the benthal population and of its biomass has not yet been satisfactorily studied.

These conclusions are supported by the study of the distribution of fluvial fish within a single basin. The increase of qualitative diversity from small rivers to large ones has been shown so far back as by Sabaneyev ([8]). German and American writers suggested to subdivide rivers into districts according to their ichthyofauna. On the ground of works by Warpakhovsky ([9], [10]) and of my treatment of statistical material on the fishery of the rivers of the Ivanovsky district, rivers of the Volga—Caspian basin may be subdivided into the following districts. The first district of the river head is inhabited only by the loach, minnow (*Phoxinus*) and gudgeon, in some sections also by the grauling and river-traut, which makes it much alike the «Bachforellenregion» of the German writers. The second district, in the river head, too, is characterized by the appearance in addition of the perch, pike, dace and burbot, and in the tributaries of the Middle Volga, of the graining. This district is also accessible to the chub, ide and ruffe which are present in small numbers and largely as young. In the third district the quantity of ruffes, chubs and ides, settling at the various biotopes of deep and shallow water, attains large figures. Young bream and *Blicca björkna* also penetrate here in small numbers. The fourth district is characterized by the number of bream rising to important figures; this fish becomes predominant in this district of large rivers. The fifth district is distinguished by the appearance of *Aspius aspius*, sheat-fish and sandre (and of *Luciperca volgensis* in the Middle Volga). In the sixth district *Pelecus cultratus* and sterlet appear in great numbers. *Pelecus cultratus* penetrates to the lower reaches of rivers of medium length, ascending to about 150—400 km of length, while the sterlet ascends as high as to 400—500 km. The next districts are probably characterized by a consecutive appearance of the caspian *Acipenseridae*, caspian *Cyprinidae*, *Clupeidae*, of the lamprey and whitefish, but at the time being they cannot be clearly delimitated.

Many tributaries have no more than one, or but a few first districts. It is noteworthy that the majority of the upper-reach fishes are distributed all along the course of a large river (except its delta), and are more numerous there than at the upper reach. This biological unity of the river is due to an increased diversity of the biotopes along the course of the river, to the appearance of new food elements which are devoured by the fishes of the upper reach. The biological unity of a river is also illustrated by the distribution all over its length of some *Oligochaeta*, of *Chironomidae* larvae, etc.

The distribution of fish species is markedly affected not only by regional or basinal, but also by general and local particularities of a given river: the sluggish flow and marshy character of a river bring about the appearance of large

quantities of crucian and tench, the reduction in the number of chub and bream; etc. If a river takes its origin from a lake, the first two — four districts are missing. The appearance of rapids in the middle and lower reach leads to the formation of a mixed ichthyofauna, consisting of elements of the upper reach and of a given district of the river. The sea-side district is distinguished by a decrease in the number of fluvial fish. The benthic population of the river may possibly also obey this rule of distribution.

The unity of the river structure all along its course makes us base all our hydrobiological estimates and characteristics on the deep stretches of the meander and on the sand bars of a given district instead of the commonly adopted manner to estimate the productivity, biomass and benthos density for separate grounds only. The estimation of the biomass for the Upper Volga (sixth geomorphological district) gave for the deep portion of the meander the mean figure of the biomass 32.2 g per 1 m^2, and 9.15 g for a sand bar. For the whole meander, deep water + shallow water, the mean biomass fluctuated between 28.68 and 29.75 g per 1 m^2. From the data by Jadin ([11]) for the upper reach of rivers, and those by Neizvestnova-Jadina ([12]) for the lower reach of the Oka, one may judge of the value of the biomass of the deep water + shallow water in those districts of the river but approximately, in so far as the estimates have not been related with the structural elements of the river and these districts. In fishery all the estimates should also be related to the structural elements of the river rather than to its length or area units.

The problem of the river as a whole can neither be posed nor solved correctly unless the structure of the river and the distribution of organisms have been studied in their general and particular features.

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PALAEOBOTANY

A NEW GENUS OF FOSSIL CONIFERS *PAPANINIA INVOLUCRATA* FEDIN

By A. Kh. FEDIN

(Communicated by W. A. Obruchev, Member of the Academy, 15. V. 1943)

The specimen of rock studied was found in 1934 by T. N. Spizharsky (1) on Franz Joseph Land (within the region Mary Harmsworth cap, on Alexandra land). It is a fragment of highly mineralized coal, a so-called «silica nodule». The rock of this nodule, containing the pyritized cone, consists mainly of vegetable remains of the conifer.

The cone consists of numerous spirally arranged spade-like scales. Each scale up to the very top of the cone carries two winged fully developed seeds with a resin-bearing cavity at the base of the wing. By all its characters the cone should belong to a typical *Coniferum* fam. *Pinaceae*. Closely related forms are to be sought among the representatives of the subfamily *Abietoidae*, but it cannot be identified with any of the genera of this subfamily, from which it differs in a number of morphological and systematic characters.

The only fossil genus, closely approaching it, is the genus *Elatides*; and a single species with this, namely *E. curvifolia* Dunk. found in Spitzbergen and described by Heer (2). According to Florin, this species is most widely distributed in the Lower Cretaceous deposits on Franz Joseph Land. The cone is distinguished from those of genus *Elatides* Hr. by a gentler curvature of its axis and the spade-like shape of scales which in *Elatides* are oval with a pointed end. The fact that the scales of *Elatides* are monospermal, as suggested by Heer, is questionable.

Having no grounds to refer the cone investigated to any genus of the recent or fossil *Pinaceae — Abietoideae*, the author describes it as a new genus—*Papanínia involucrata* Fedin.

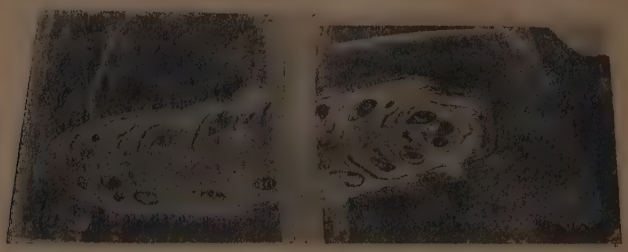
Papaninia involucrata Fedin gen. et sp. syn. *Piceostrobus elegans* Jarm (nomen nudum)

Cone non-opening, 5 cm long and 1.3—1.8 cm across; cylindrically elongated, slightly curved, top and base rounded-obtuse, scales tightly adhering. Fruit, bearing scale very long, spade-like with apex obtuse; maximum length, 2 cm. The scale, thinning out gradually, terminates in an undulating edge and seems to encircle the upper part of the cone. The covering scale, 4 mm long, lying on the external side at the cone's base, terminating in a thin edge. Thickness of its lower part is almost equal to a half of the length. Seeds numerous; spirally arranged, with a thick membrane. Seed reversely ovate, the side turned to the axis being more or less symmetrical to the external one. Length of seeds 3.5 mm; width 1.5 mm. The wing corresponds in shape to the longitudinal half of the fruit-bearing scale without, however, reaching its apex. Length of wing is four to five that of seed. Wing encircling the seed from below and containing a resin-bearing cavity.

The wood of the specimen investigated is represented in thin-sections mainly by cross-sections, partly tangential and radial, secondary wood without pith

and crust predominating (in young shoots the pith and typical leaf-cushions are preserved) possessing a typical structure of *Coniferae*. The presence of vertical and horizontal resin ducts with a thick-walled epithelium, as well as the abundance of wood parenchyma, is evidence of the wood belonging to the family *Pinaceae*, subfamily *Abietoideae*. The presence of resin ducts, running both in vertical and in horizontal direction, justifies a comparison of the fossil wood under consideration with that of the general *Pinus*, *Picea* and *Larix*, excluding at the same time the genera *Abies*, *Cedrus*, *Tsuga*, *Taxus*, *Cupressus*, *Podocarpus* etc., which lack normally developed resin ducts. The presence of a thick-walled epithelium in the resin ducts excludes from the comparison also the genus *Pinus*. Neither can it be referred to fossil *Araucarioxylon* Kr., *Cupressinoxylon* Goth., *Cedroxylon* Kr., *Taxoxylon* Kr., since they lack resin. From the presence of resin ducts, and the structure of pores in the thracheids and radial parenchyma the wood investigated is identical with the characters of genus *Pityoxylon* Kr., in particular, though not completely, with *Pityoxylon eiggense* (Whit) Kr.

In eighteen thin-sections over fifty cross- and longitudinal sections of needles of the most diverse forms have been found, similar both in outlines and in anatomical structure. The principal shape of cross-section of the needles is an elongated-rhombic one. The epidermis consists of regular, tabular, tightly packed cells with thickened external walls and thinner, slightly convex inner walls, occasionally the cells of the epidermis are interrupted by stomata, small locking cells on the side convex from the axis of the needle. The stomata are slightly embedded in the epidermis and with their cavity break the hypoderm bounding



on mesophyll. The cells of the hypoderm are arranged mainly in one layer, at some places in two—three layers forming projections in the shape of triangles. The shape of cells is irregular, rounded-square, their walls are very thick; cavity dot-like, sometimes in the shape of a very small square. The mesophyll consists of homogeneous, rounded, large parenchymatous cells with characteristic plicated walls. The plicated nature of the cells of the mesophyll is observed in a number of species of *Picea*, for example, *P. Breweriana*. Moreover, a number of recent pines, such as *Pinus Lambertiana*, *P. fierlis*, *P. monophylla*, *P. aristata*, have no plicated parenchyma. On the cross-section in the mesophyll, symmetrically in two opposite corners of the section, following the long axis, two resin ducts are located, closely adjoining the hypodermis and somewhat projecting into it. The lining cells of the resin ducts are comparatively small, with thin inner walls and thickened external ones. Around the resin ducts there is one layer of thin-walled cells, similar to those of the hypoderm. In the centre of the mesophyll—the conveying cylinder of a rounded, more frequently oval shape, surrounded with a ring of endodermis, consisting of 21—24 comparatively large cells, flattened and elongated parallel to the surface, with thickened external walls.

The endodermis is followed by elongated cells of the pericycle which surround two fibrous vascular bundles separated by a band of three rows of very narrow and comparatively small cells. Each bundle consists of thin-walled elements corresponding to the floem, and thick-walled ones resembling tracheids,

corresponding to the xylem. No complete division into two bundles, as it is usually the case with most of the species of genus *Pinus*, is observed. In some others such as, say, *Pinus Strobus* L., *P. Lambertiana* Dougl., *P. flexilis* Jams, *P. edulis*, *P. aristata*, etc., the fibrous-vascular bundles lie close to each other and resemble very much most of the species of the genus *Picea*. All these characters make the needles studied very similar to genus *Picea* and the genera closely related to it, viz. *Larix*, *Abies*, *Tsuga*, i. e. point to their reference to family *Pinaceae*, subfamily *Abietoideae*.

The above peculiarities in the combination of anatomical characters of the conifer considered, permit it to be placed in a separate group under the name of *folium piceo-pineoides* Fedin, since it combines characters separately typical of different genera of recent conifers.

To sum up, it has been established that the rock fragment investigated contains exclusively remains of conifers belonging to the family *Pinaceae* subfamily *Abietoideae*. It should be assumed that these remains, cones, wood, and needles, either refer to three different types of conifers, or belong to the same type which possessed mixed characters peculiar to different species of the recent representatives of *Pinaceae — Abietoideae*.

The former assumption seems doubtful because of the facial peculiarities, for then we should adopt within a very small area existence of three very closely related conifers referring to one subfamily, which is hardly probable. The latter assumption is more probable, although it should be borne in mind that the cone, wood, and needles have been found in a disjoined condition. This problem cannot be solved unless allowance be made for the taxonomy of fossil plants. «Species» and «genus» of fossils will necessarily have a larger scope than the «species» and «genus» of recent plants. Therefore when describing the fossil cone as a new genus *Papaninia*, the author is inclined to refer both the wood of the *Pityoxylon eiggense* type investigated, and the needles *folium piceo-pineoides* of the above described type also to this genus (*Papaninia*). The nomenclature type of genus *Papaninia* is presented by the cone of *Papaninia involucrata*, and all the subsequent discoveries and findings should be referred to this type.

In the specimen studied no vegetable remains were found that could have been classed amorg other taxonomic groups.

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HELMINTHOLOGY

SEASONAL ADAPTATION REACTION (DESTROBILIZATION) IN CESTODES PARASITIC OF NON-MIGRATORY BIRDS

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While studying the helminthic fauna of birds hunted on an industrial scale in West Siberia, we happened to encounter a new curious example of seasonal adaptation in some cestodes parasitic of the *Tetraoninae* and other non-migratory birds; the essence of the phenomenon consists in the following.

Since October and even somewhat earlier there is an abrupt drop in the intensity of the cestode invasion, and a somewhat less sharp decrease in that with nematodes.

Thus, according to our data comprising a total of 463 autopsies (256 made in 1940, 200 in 1941, and 7 in 1942) it has been established that the infestation with cestodes of black and white grouses, as recorded for these years, amounted to 100 per cent within the period from the end of May to June, inclusively. In August it was 80 per cent, in September 69.5, in November 50, and in December 20 per cent.

This fact may be interpreted in various ways. In the first line, there is the immunity which has been reported by many authors to increase towards fall both in adult birds and young. But the principal cause lies in the diet which grouse and pheasant birds adopt with the approach of autumn.

It stands to reason that, being biohelminths or heteroxenian parasites, the cestodes cannot possibly give new invasions after the birds have passed to a purely vegetable diet. And in fact, since August, when berries and seeds become prevalent in the food of *Tetraoninae*, the number of cestoses begins to decrease gradually.

According as the birds pass to coarse wood diet (tassels and buds of birch and willow, needles of conifers, etc.,) since the end of October and during winter, the cestodes occur still less frequently. However, contrary to the current idea (Mannteufel, Wolter, 1933) that under the influence of their specific winter diet the grouses become entirely freed of helminths, the latter do not vanish altogether from the intestine of these birds.

Thus, the examination of about 300 winter (December-February) grouses, hazel-grouses and white grouses from the Omsk district, has given the following figures of infestation with cestodes for this season: black grouses 20 per cent, white grouses 50 per cent, hazel-grouses 13.5 per cent, and partridges 68.8 per cent. We have been studying the seasonal variation of the helminthic balance in birds hunted for industrial purposes for the last three years, and found that early in winter the cestodes parasitic of *Tetraoninae* intestine (*Raillietina urogalli*, *Raillietina cesticillus*, *Rhabdometra tomica* and some others) cast off their strobila, and may remain in the mucous of the intestine throughout winter in the

form of a scolex alone, with 5—8 anterior segments. In the case of an insufficiently thorough examination of the intestine (especially when made without magnifying glass), the presence of parasites might easily be overlooked, and the intestine of winter grouses could be considered free of the helminths.

Scolexes used to be encountered along with integer individuals of tapeworms (in 21 per cent of cases) beginning with September, when fresh infestation could take place. Since October, after the falling of snow and setting in of frost, which took place in 1940, we found scolexes in 100 per cent of black grouse, white grouse and hazel-grouse.

It is obvious that in this case recent infection was out of the question, and it should be considered that the scolexes have been left behind after destrobilization.

The examination of the heads has fully supported this conclusion: all of them looked perfectly developed, and to each were attached from five to eight old proglottids, often partly decayed.

Thus, a material correction should be introduced into the conclusions arrived at by earlier authors: in spite of the coarse wood-diet (needle; buds) to which the *Tetraoninae* are confined in autumn, no total dehelminthization takes place.

The nematodes do not seem to leave their hosts, while the cestodes show only a peculiar seasonal adaptation; consisting in a temporary reduction of the strobila. Its proliferative part, together with the scolex, is preserved throughout winter, whereas the generative part is cast off. The phenomenon, termed by us «destrobilization», is a useful, adaptive one: during the hard time of food deficiency it spares the host's organism from excessive exhaustion, thus contributing to the survival of the parasite. As to the loss of the generative part of the worm's body for the winter season, when the heteroxenian species of parasites have no chances to develop progeny, it does by no means affect the thriving of the species.

The scolexes are preserved in the host's intestine up to the end of winter: the white grouses from Sale-Kharda (polar circle) were found to contain them as late as in February.

By the end of winter young strobilae begin to grow from the heads that have wintered in the host's intestine. The birds that were killed early in spring proved already to be severely infested with cestodes. A very curious picture of invasion has been offered, for example, by an individual of grouse (*Lyrurus tetrix*) No. 595 (74) killed on March 16th, 1943, in the Sargat district of the Omsk province.

By this time a solid snow covering still lay over wood and field, and the temperatures run as low as from —10 to —27°C. Gizzards and stomachs of the birds were found to contain nothing except birch tassels and buds with fragments of young shoots. So the possibility of a new invasion with cestodes was out of the question.

Nevertheless, upon the dissection of this specimen, its small intestine was found to contain 202 individuals of the cestode *Rhabdometra tomica* Cholodk., almost exclusively in the form of scolexes with strobilae that have just started growing. The largest strobila, quite a young one, was no more than 38 mm long.

No less interesting is another example of strobilae grown from overwintered scolexes, offered by a specimen of white grouse (No. 162) killed on April 8th, 1940, in the vicinity of the station Isilkul of the Omsk railway. This bird has been found to contain 354 cestodes, 229 of them in the form of scolexes of *Rhabdometra tomica* Cholodk,, bearing 4—8 segments each, 123 young cestodes of the same species from 2 to 8 cm long, and 2 very large individuals of *Raillietina urogalli* Modeer, 40 and 39 cm in length. In this case both recent infestation (the snow covering in 1940 melted away as early as during the first fortnight of April), and the development of at least two big *R. urogalli* out of overwintered scolexes might have taken place. On account of phenological conditions the bird could

not be possibly infested anew until 8—10 days prior to dissection; within this period the worms could, of course, not have attained a length of 0.5 of a meter.

Shipley (1) reports a case when a worm of this species, 35 cm long, was found in a young grouse no more than three weeks of age. Consequently, in our case infestation should have taken place at least a month before the moment the bird was killed, viz. about middle March, when the snow covering was still continuous and no fresh invasion could possibly occur.

The material at our disposal testifies of that the adaptation of cestodes is based on more general causes depending not only on the antihelminthic properties of the seasonal diet, but on some causes of historical nature, being a seasonal adaptation reaction of the parasite.

The reaction is therefore inherent not in all cestode species, but only in such in which it had been developed historically. These are species parasitic of northern non-migratory birds; in the first line the adaptation to the seasonal (winter) variation in the life conditions of the host has been extended to cestodes obligate in the strict meaning of this term, which have been for a long time linked with a given non-migratory species of host.

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